BMT Murray Fenton Edon Liddiard Vince Limited

No. 3623

STUDY ON THE ECONOMIC, LEGAL, ENVIRONMENTAL AND PRACTICAL IMPLICATIONS OF A EUROPEAN UNION SYSTEM TO REDUCE SHIP EMISSIONS OF SO_2 AND NO_x

August 2000

Final Report

for

European Commission Contract B4-3040/98/000839/MAR/B1

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1. INTRODUCTION

This is the final report to the European Commission D-GXI for study contract B4-3040/98/000839/MAR/B1. The contract was signed in early February 1999 and the study commenced with an initial meeting in Brussels on 4th February 1999. The study was conducted before the submission to IMO (MEPC 44) to designate the North Sea as a SO_x Emission Control Area. The submission was made in December 1999 and adopted in March 2000.

The aim of the study is to consider, analyse and recommend policy options to further the objective of reducing the harmful environmental impact of emissions of SO_2 and NO_x from ships operating in European waters. The Technical Annex (Annex A to this report) to the contract specifies particular measures to be considered in the study:

- environmentally differentiated port dues related to emission of SO_2
- environmentally differentiated port dues related to emission of NO_x
- regulated (reduced) sulphur content in marine fuels

The sulphur in fuel levels to be considered are 1.5%, 1% and 0.5%. The NO_x emission rates are 12, 7 and 2 g/kWh.

The policies that have been considered are of both a regulatory and an incentive-based nature. They relate to restricting the sulphur content of marine fuels sold and consumed in Europe; modifying the combustion process so as to restrict the generation of NO_x; and cleaning exhaust gases to reduce emissions.

The effectiveness of any policy depends on a complex interaction of economic, operational, technical, legal and environmental factors, and the results of the analyses of the policy options are the important final deliverables of the study. First, however, the context within which the environmental aims are set and the nature of shipping in Europe is described to ensure that the analysis and conclusions derive from a valid and adequately quantified set of assumptions.

A number of prior studies have contributed valuable information. It has not been the purpose of this study to reproduce such efforts, but it has been appropriate to examine the validity of the basic assumptions they used.

The Appendices to this report contain the greatest level of detail and have been contributed by the individual experts. The main chapters of the report present the salient points and discuss the essential issues, but the reader is referred to the relevant appendices for more detail.

Analysis of the policy options is given in Chapter 5, and the conclusions and recommendations are presented in Chapter 6.

2. THE NEED TO REDUCE ATMOSPHERIC EMISSIONS IN EUROPE

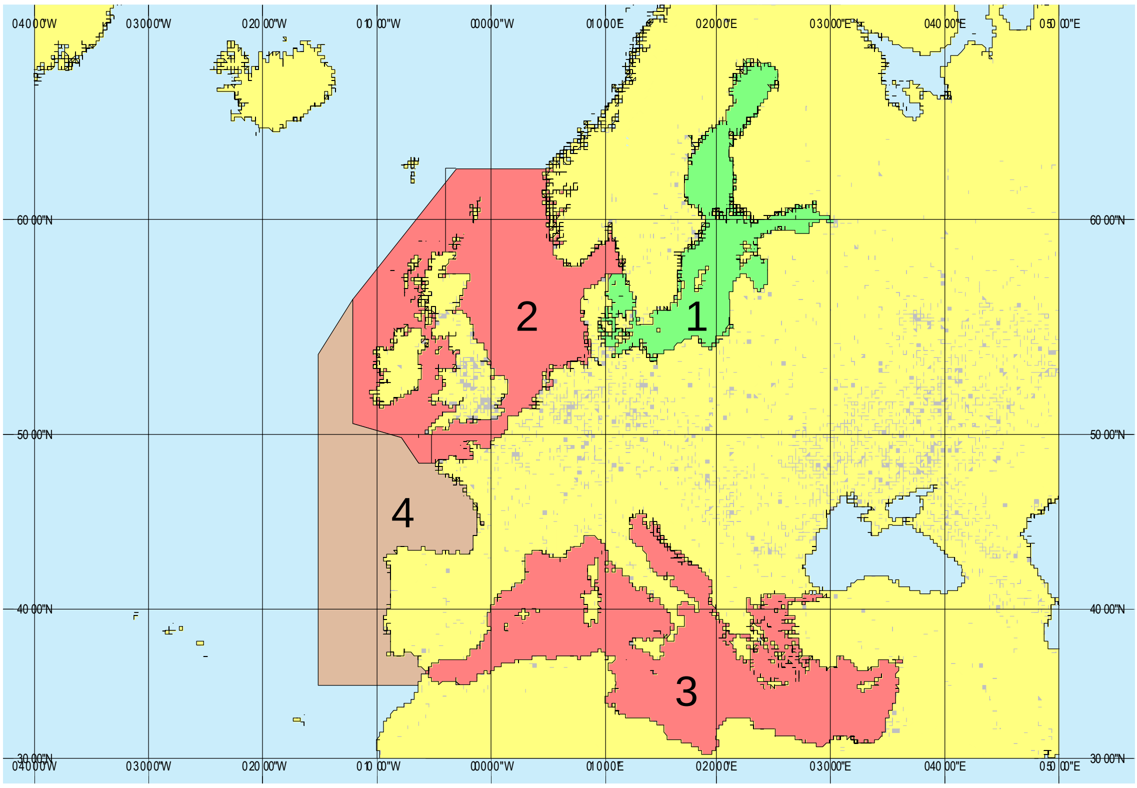
The European air mass is a complex dynamic meteorological system influenced by both maritime and land mass effects. 'European waters' regarded as relevant in this respect are depicted in the map below (Figure 2.1). These are divided into the following sea areas: the Baltic (1), the North and Irish Sea (2), the Mediterranean (3) and the N E Atlantic (4), in accordance with MARPOL definitions, with the exception of the N E Atlantic, which has a more arbitrary definition. The North Sea area defined here is an expansion to that proposed in IMO doc. MP/CONF.3/16 (July 1997), for a North Sea SO_x Emission Control Area. Specific definition of the sea areas involved is given in Appendix 1.

It has been well reported that many European countries have experienced the adverse effects of air pollution, both from local sources and as a consequence of longer-range, including transboundary, transport of pollutants. It has been estimated that approximately 70% of the total population of all the European cities with monitoring stations are exposed to SO_2 levels above the lower EU guide value and for NO_2, a number of cities with about 40% of the population have an average level above the EU guide values. Studies for the Convention on Long-range Transboundary Air Pollution (see, for example, fig.4 of MP/CONF.3/16 (July 1997)) show that significant areas of the UK, Scandinavia and Central Europe receive sulphur deposits in excess of critical loads (a level below which significant harm to the environment is not judged to occur). IIASA (1999 –7th Report) gives the data set out in Table 2.1 below.

Table 2.1 Ecosystems with acid deposition above their critical loads for acidification for 1990, and 2010 according to current projections. (Data from Table 2.7, IIASA, 1999 – 7th Report).

	PERCENT OF ECOSYSTEMS	
	1990	2010
Austria	47.6	3.3
Belgium	58.4	22.1
Denmark	13.8	2.3
Finland	17.2	4.3
France	25.8	0.7
Germany	79.5	15.8
Greece	0.0	0.0
Ireland	10.7	1.3
Italy	19.6	0.7
Luxembourg	66.7	5.9
Netherlands	89.3	60.4
Portugal	0.0	0.0
Spain	0.9	0.2
Sweden	16.4	4.1
UK	43.0	12.3
EU-15	24.7	4.3

Figure 2.1 Map of European Sea Areas



Marine study area	Description	Area (km^2)
1 – Baltic	The Baltic Sea along with the Gulf of Bothnia, the Gulf of Finland and the entrance to the Baltic Sea bounded by the parallel of the Skaw in the Skagerrak at 57 44.8 N	422,000
2 – Northwest European waters	The North Sea, the Irish Sea and its approaches, the Celtic Sea, the English Channel and its approaches and part of the North East Atlantic immediately to the west of Ireland. The area is bounded by lines joining the following points: • 48° 27'N on the French coast • 48° 27'N; 6° 25'W • 49° 52'N; 7° 44'W • 50° 30'N; 12°W • 56° 30'N; 12°W • 62°N; 3°W • 62°N on the Norwegian coast • 57° 44.8'N on the Danish and Swedish coasts This is the area defined in Annex I of MARPOL.	1,572,597
3 – Mediterranean	The Mediterranean Sea including the gulfs and seas therein with the boundary between the Mediterranean and the Black Sea constituted by the 41° N parallel and bounded to the west by the Straits of Gibraltar at the meridian of 5°36' W.	2,505,000
4 – Northeast Atlantic		1,511,801
	Total	6,011,397

Appendix 2 reports in some detail on the chemical transformation processes that render combustion exhausts harmful to the environment, both in terms of air quality and acidification. In some parts of Europe (notably Scandinavia) acidification has been a major environmental threat. In other areas, particularly the Mediterranean, ground level ozone is the overriding problem of concern. The harmful effects impinge upon:

- Health - adverse effects on human health, especially for people susceptible to respiratory problems. NO_x, along with volatile organic compounds (VOC), is also involved in a series of photochemical reactions which can lead to tropospheric ozone (O_3) increases - which may also have deleterious effects on human health (as well as crop yield and natural vegetation).

- Material Damage – acceleration of material corrosion.

- Ecosystems - SO_2 and NO_x are the primary components of acid deposition and this is the primary way in which these emissions affect ecosystems. Nitrogen deposition can contribute to the eutrophication of terrestrial, freshwater and marine ecosystems, affecting among other things the biological diversity of these ecosystems.

- Soil - The primary effect of SO_2 and NO_x emissions on soil is through soil acidification. This leads to the leaching out of plant nutrients, such as potassium, calcium and magnesium, which in the long term may cause nutrient deficiencies, thus threatening the productivity of soils. Acidification may also result in increased soil concentrations of aluminium (Al) and other toxic metals.

- Freshwater - Acidification of freshwater life can result in widespread fish kills, have repercussions on other animal and plant life and alter the overall ecosystem balance. Other biological changes include a decline in the number of species of phytoplankton.

- Flora and Fauna - Under acidifying conditions, nitrogen-loving plant species expand in a normally nitrogen-poor environment. Heaths, raised bogs, unfertilised hay meadows and grazing land are examples of habitats that risk losing much of their diversity. Whole forests have died off as a result of acidification in the mountain regions of Central Europe. In general, the additional nitrogen presents a greater threat to biodiversity than soil acidification, as ecosystem composition is determined to a large extent by the availability of nitrogen, which is usually in deficit. Certain species of birds are affected by acidified water and the ingestion of more aluminium and less calcium than usual. The alteration of habitats is another problem, e.g. thinning of foliage in spruce trees, reduces the living space for spiders and other insects that inhabit the branches, thus affecting the birds that live in coniferous forests. Mammals are also affected by habitat alteration. Elevated concentrations of cadmium have been found in the liver and kidneys of elk and roe deer in southern Sweden, which is thought to be the result of the metal's increased mobility following soil acidification.

As a result of the considerable concerns about acidification and poor air quality extensive action has been taken internationally, regionally and nationally through a range of Conventions, Directives and economic instruments. These are described in detail in Appendices 2,3 and 4.

Directive 96/62/EC, the Air Quality Framework Directive, deals with ambient air quality assessment and management, and new air quality standards have been developed, particularly by the WHO (1999 Human Health Air Quality Guidelines) and the EU (Forthcoming EU Air Quality Standards (COM (98) 386)). The revised WHO Air Quality Guidelines for Europe also include a range of values for different degrees of protection of ecosystems from exposure to SO_2 and NO_x.

At the Environmental Council in December 1995, the Commission was requested to develop a proposal, by the beginning of 1997, for a Community Strategy To Combat Acidification. In line with the 5th Environmental Action Programme the Council confirmed the political long-term goal of not exceeding critical loads and levels. The objectives of the Strategy were to reduce beyond existing commitments emissions of SO_2, NO_x and ammonia (NH_3). The Commission proposed to reduce the area of ecosystem in the EU at risk from acid rain from 6.5% on the basis of existing commitments to 3.7% by 2010 (CEC, 1997). The Commission's study (conducted by IIASA) showed that even with the most ambitious abatement programmes for reducing acidifying pollutants the ultimate target of never exceeding critical loads could not be achieved by 2010. In line with the December 95 Environmental Council's decision the Commission therefore followed the 'gap closure' approach which aimed to reduce the difference between the level of ecosystem protection in 1990 and the 100 percent ecosystem protection by the year 2010. The Commission felt that the most appropriate interim target was a 50% gap closure.

The ultimate objective is to make further progress towards the ambition of achieving no exceedence of critical loads in the EU. The Second UNECE Sulphur Protocol is designed to deliver substantial reductions in SO_2 emissions over the next 10 years, particularly in northern Europe. As a consequence, sulphur deposition levels are anticipated to fall by a factor of five or more in the critical areas of Europe compared to peak levels in 1980. When this is added to substantial NO_x reductions from other sources, significant progress towards achieving the critical loads is anticipated. Exceedences are, however, expected to remain in limited areas.

The IIASA studies (e.g. 7th report, Jan 99) for the Commission on strategies to combat acidification typically compare 1990 emissions, likely 2010 emissions given current commitments and plans, and the required levels to achieve the “50% gap closure”. Table 2.2 below illustrates the magnitude of the expected changes and the reductions required for further gap closure.

Table 2.2 Reducing emission levels in Europe

EMISSION	1990 EMISSION (MT/YR)	2010 EMISSION (MT/YR) CURRENT PLANS	2010 EMISSION (MT/YR) REQUIRED FOR “50% GAP CLOSURE” (H1)
SO_x from EU-15	16.5	4.7	3.6
NO_x from EU-15	13.2	6.8	5.9

Estimates of emissions from marine traffic are dealt with in Appendices 1, 2 and 7. Estimates have varied considerably between studies and are also subject to “definition variability” (i.e. differences according to geographical areas and ship populations considered). The Appendices derive the main statistics that are given in Tables 2.3 and 2.4, which suggest the volumes and relative contributions of shipping emissions. References to Appendix 1 (A1) in this respect, relate to new estimates derived in the course of this study.

Table 2.3 Shipping emissions of SO_2

	Emission (Mt/yr)	% of EU-15 1990	% of EU-15 2010 "current plans"
World shipping (Corbett, 99)	8.5		
World shipping (A1: Table 1.8)	9.2		
N Atlantic (Corbett, 99)	4.4		
NE Atlantic (LR, 95)	1.4	8%	30%
N Sea & NE Atlantic (Tsyro, 97)	1.1	7%	23%
N Sea & NE Atlantic (EMEP, Table A6.4)	1.4	8%	29%
N W European Waters (A1: Table 1.8) & N E Atlantic (A1: Table 1.8)	1.1	6%	23%
Baltic (MariTerm, 91)	0.1	1%	2%
Baltic (EMEP, Table A6.4)	0.2	1%	5%
Baltic (A1: Table 1.8)	0.3	2%	6%
Mediterranean (A1: Table 1.8)	0.4	2%	8%
Mediterranean & Black Sea (LR 2000)	1.2	7%	26%
SO_2 from bunkers sold in Europe (A1)	2.6	16%	55%

Table 2.4 Shipping emissions of NO_x (see Appendix 2)

	Emission (Mt/yr)	% of EU-15 1990	% of EU-15 2010 "current plans"
World shipping (Corbett, 99)	10.1		
World shipping (A1: Table 1.8)	11.0		
N Atlantic (Corbett, 99)	5.3		
NE Atlantic (LR, 95)	1.9	14%	28%
N Sea & NE Atlantic (Tsyro, 97)	1.6	12%	24%
N Sea & NE Atlantic (EMEP, Table A6.4)	2.0	15%	29%
N W European Waters (A1: Table 1.8) & N E Atlantic (A1: Table 1.8)	1.3	10%	18%
Baltic (MariTerm, 91)			
Baltic (EMEP, Table A6.4)	0.4	3%	5%
Baltic (A1: Table 1.8)	0.3	2%	5%
Mediterranean (A1: Table 1.8)	0.5	4%	7%
Mediterranean & Black Sea (LR 2000)	1.7	13%	25%

Emission estimates designated *LR2000*[1] are very recent and have yet to be thoroughly reviewed. They are significantly higher than previous estimates and suggest a level of emission in the Mediterranean similar to that in all NW European waters (including the N Sea) plus the Baltic.

Whatever the precise emission levels, percentages such as those listed above illustrate how much the expression of relative contribution from shipping is a "moving target" (as the overall total reduces, so shipping's contribution may grow in relative, but not absolute, terms) and also, how much care must be taken to compare like for like statistics. The figure for SO_2 from bunkers sold in Europe is not intended to

[1] Lloyds register Study Report for European Commission D-G Environment: Marine Exhaust Emissions Quantification Study – Mediterranean Sea, FINAL REPORT 99/EE/7044, K.A. Lavender, Feb 2000

represent pollution generated in any particular sea area, rather it is helpful in putting into perspective the different issues relating to ship emissions. It can be concluded that shipping's relative contribution to acidifying emissions is likely to change, on the basis of current ship performance, from of order 10% in 1990 to of order 30% in 2010. Given that the 2010 predictions will still lead to exceedence of critical loads in parts of Europe (in excess of 4% - table 2.1), it is evident that a source as large as 30% needs careful attention. Indeed the IIASA modelling suggests that achievement of 2010 targets can be achieved at lower cost if the shipping sector makes a significant contribution to overall reductions.

The analysis of legal issues suggests that a European regional approach can be effective and justified under certain circumstances. Appendix 4 observes that EC Member States, acting alone or in concert as the EC, have varying degrees of jurisdiction to prescribe regulatory requirements concerning SO_2 and/or NO_x emissions, although for practical and policy reasons, emphasis should be placed on in-port measures. Given the evidence that much of the vessel-source air pollution affecting Europe occurs within territorial waters, the Commission might wish to consider requiring Member States to prescribe and enforce relevant standards applicable to their territorial seas. The legal reasoning is complex and is dealt with in detail in Appendix 4. Chapter 3 provides a summary of the main points at issue and resulting recommendations.

The main marine "highways" in Europe include the near coastal routes through the English Channel and along the north coast of continental Europe, the western part of the Bay of Biscay, the Straits of Gibraltar and the route to the Suez Canal.

The emphasis on port vicinity and territorial seas is supported by an analysis of emissions in the 50 and 100 nautical mile zones in the North Sea, where the EMEP study found (Appendices 2 and 6) that the largest emissions were associated with the routes for busy traffic close to the coast in the western and southern parts, and particularly, in the English Channel. These conclusions are clearly shown in the Lloyds 1995 Marine Emissions Report, and similar patterns have been generated by this study (Fig. 2.2 from Appendix 1, see Figures A1.13 and 14).

To evaluate the policy options outlined in Chapter 3, relationships between ship emissions and their environmental impact must be demonstrated. This, of course, is the subject of the detailed EMEP modelling. Its results are reported and used in Appendix 6. Figure 2.3 clearly illustrates the strong local impacts closely related to the high emission areas of the North Sea. Also, according to Swinden (Appendix 2) the reduction in deposition from a ship will be at least two orders of magnitude at 12 nautical miles. Lowles and ApSimon (1996) found that a significant proportion of sulphur deposition in coastal land areas, between 75 and 80% (77 - 80% according tp Lowles 1998) was due to emissions that occurred within territorial waters.

The countries proposing a North Sea SOxECA at the IMO in 1997, suggested "there are no major differences in the transportation and deposition patterns between emissions from land-based sources and ship emissions". As a result emission reductions are treated as equal, independent of their source. Equal treatment of all emissions is inevitably an oversimplification, however. For example, road traffic pollution dispersion clearly differs from power station stack dispersion in character and in effect.

Other modelling studies are limited and often incomplete in defining the detailed source terms and dispersion models. Appendix 2 describes these and also the relatively short-range impacts that these models predict.

Given the proximity of the heavy traffic lanes to the coasts of Europe and the growing significance of the totality of ship relative to land emissions, the pursuit of policies to cut SO_2 and NO_x emissions to air from ships is clearly justified. A discussion of the available policies and constraints follows in Chapters 3, 4 and 5.

Figure 2.2 SO2 emissions from ships from Appendix 1

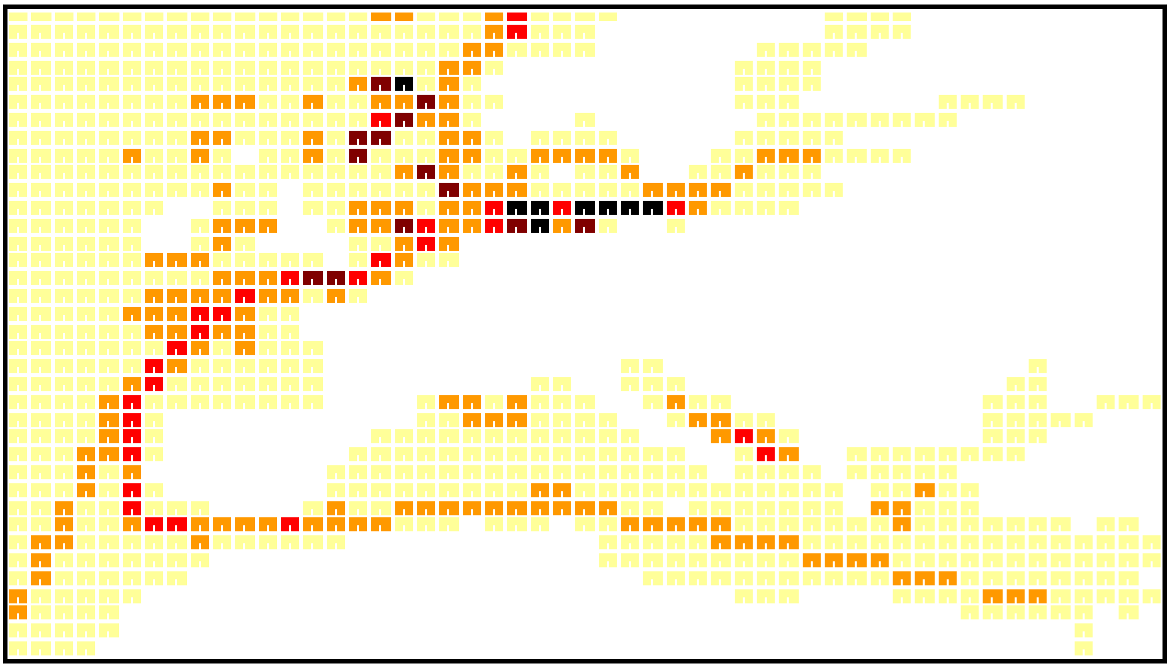
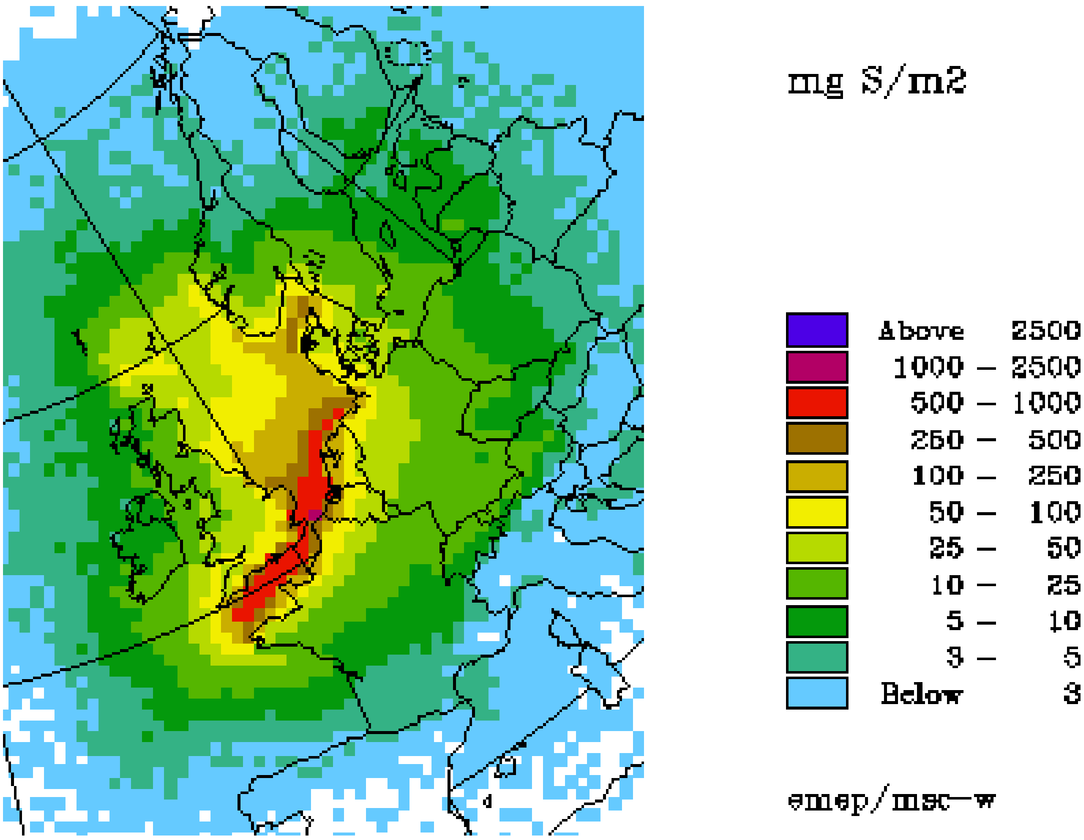


Figure 2.3 1997 deposition of oxidised sulphur from the North Sea



3. LEGAL AND POLICY CONSIDERATIONS

Appendix 4 examines the legal, and related policy, aspects of the two potential EC instruments being studied by reference to five 'baselines': general principle (paragraphs A4/10-16); general public international law (paragraphs A4/17-209); regulatory treaty law (paragraphs A4/210-300); EC law (paragraphs A4/301-432); and national laws (paragraphs A4/433-436). The most important of these baselines is public international law, which proscribes limits to Member States' and EC action equally: '[I]n so far as Member States under International Law have jurisdiction with respect to... environmental aspects of shipping activities, the Community is entitled to exercise those competences. Given the broad competences of the [EC] Treaty, the scope of the Community's competences follows those of the Member States under International Law': Nollkaemper and Hey, 1995, p. 287 (for full references for this chapter, see bibliography to Appendix 4). The Appendix also looks at compliance aspects (paragraphs A4/437-452) and the possibility of requiring 'cold ironing' of vessels in ports (paragraph A4/453). The legal picture is very complex. This Section of this Chapter aims to set out only the salient points and our conclusions (with cross-references to the Appendix), but the reader is strongly advised to read the Appendix in full.

Each of the two potential instruments raises very different legal questions from the other, particularly in the sphere of public international law, and to a lesser extent in EC law. The optimum approach to reducing ship emissions affecting Europe might well, however, be through use of a <u>combination</u> of regulation and market-based instruments. The latter have been successfully used in both national and regional contexts, but it is increasingly recognised that their use should normally occur only in combination with a degree of regulation (see paragraphs A4/1 and 403). As to their use in relation to shipping, see Appendix 3.

3.1 General Principle

Ship-source air pollution should be regulated separately from incineration of waste at sea (paragraph A4/10). It should be based on a critical loads approach, bearing in mind its limitations and the need for progressive improvement of data relevant to shipping (paragraphs A4/11-13). In addition, it should seek, wherever possible, to redress the past imbalance resulting in more effective regulation of SO_2 than NO_x emissions and should progressively aim to achieve a more integrated approach to control of the different pollutants, taking account of synergies (paragraphs A4/14-16).

3.2 General International Legal Standards

There is nothing in law to prevent EU Member States seeking to tackle ship-source air pollution at the national or sub-national level, or by means of agreements entered into bilaterally or between groups of States. The acidifying effects of air pollution in Europe being recognised for the past two decades as a regional problem, however, and shipping being a global industry, global and/or regional solutions are to be preferred (paragraphs A4/18-22). Existing relevant international standards need to be sought in conventions, since the customary international law principles relevant to environmental protection, the 'no' harm' and 'good neighbourliness' principles, are in themselves insufficiently precise (paragraphs A4/23-33).

The Law of the Sea, and in particular the 1982 UN Convention on the Law of the Sea (LOSC), is the most significant 'source' from which to determine the jurisdictional scope the EC and its Member States have to establish an EC ship emissions regime. The LOSC 'entails the clear predominance of [global] international rules and standards over national laws and regulations... in respect of standard-setting and enforcement measures relating primarily to pollution from vessels (emphasis added)': Rosenne and Yankov, 1991, p. 13. The flag State has primary responsibility for implementation and enforcement of these globally agreed standards (including MARPOL Annex VI, when it is in force). The roles of port and coastal States, while growing, have traditionally been more limited.

A system of environmentally-differentiated shipping dues will be entirely port-based. Regulation of the sulphur content of marine bunker fuel, on the other hand, involves a choice between simply restricting the sulphur content of bunkers sold to shipping in EU ports and seeking to control the fuel being used by ships in ports and adjacent waters, or perhaps doing both. The first choice involves merely imposing obligations on relevant actors on EU territory (including internal waters). The second, by contrast, involves 'reaching out' to control matters beyond, as well as within, ports. It thus raises the issue whether or not an EC Member State is entitled under public international law, *qua* coastal State, to regulate beyond globally agreed, or generally accepted, international standards the content of fuel being used by foreign ships, including those in transit (i.e. not destined to call at one of its ports, thereby voluntarily submitting to its full territorial jurisdiction), in its territorial sea or jurisdictional waters, or even on the high seas beyond. This is not to deny that even port-based measures will have an 'effect' on shipping extending beyond the ports in question; it is only the exercise of jurisdiction that is geographically limited.

Being sovereign within its territory, ports and other internal waters, a Member State may, absent treaty obligations to the contrary, exclude vessels from its ports or place conditions upon their entry. It may, absent such treaty obligations, regulate, or impose environmentally-differentiated dues on, foreign vessels voluntarily present in its ports without restriction, other than those arising from: the (non-binding) rule of comity that the port/coastal State will generally not seek to exercise jurisdiction over matters considered part of the 'internal economy' of the ship; and its general international obligations.

The latter appear to be weak. The most significant restrictions that can be argued for are those arising from the temporary and voluntary nature of the vessel's presence and the geographical limits of the port/coastal State interests affected by the vessel. In particular, in-port measures that have the practical effect of imposing requirements above international standards that the vessel must comply with throughout its voyage in order to comply in port are likely to be hotly disputed. This is likely to be particularly true of 'construction, design, equipment and manning' ('CDEM') standards, which in effect travel with the ship, such that it is highly desirable to have uniform global standards. It is not clear, however, whether or not these restrictions are legal in nature. The USA being the country most assertive of extraterritorial jurisdiction, the US Supreme Court's jurisprudence is perhaps the most instructive in this regard. Its decisions go both ways, but there has been a recent trend (also seen in a recent New Zealand Court of Appeal decision) towards the view that the temporary nature of the vessel's presence places restrictions upon the port/coastal State's sovereignty. In so far as economic instruments do not have the effect of requiring adherence to a particular standard, therefore, but leave a choice of action, they are less objectionable on this ground than regulatory measures. In any event, these are all strong policy reasons for showing restraint, whichever form the instrument takes (see paragraphs A4/203-06). See paragraphs A4/4 and 128-152, especially 134-151).

These possible restrictions notwithstanding, there is a strong case to suggest that, given the difficulties surrounding the prescription of standards for off-shore waters, described below, the EC should consider prescribing only in-port measures (of either or both types), or at the most should (bearing in mind that the majority of damaging ship emissions occur close to the coast) prescribe in addition only emissions standards in the territorial sea (see esp. paragraph A4/207). In any event, the reluctance of Member States (particularly the UK) to take off-shore enforcement measures, even in the territorial sea, suggests that all relevant measures (whether in-port or off-shore) should in general be enforced in port (see esp. paragraph A4/208).

The port/coastal State, it has been suggested, may accept treaty restrictions upon its freedom to apply environmental protection measures, including a system of environmentally-differentiated shipping dues, to foreign ships calling at its ports, albeit that it will not do so merely by virtue of becoming Party to the LOSC and/or the various IMO conventions providing for port State control (see paragraphs A4/153-202). A large number of bilateral treaties of friendship and commerce are potentially relevant, and the most significant general treaty provision is likely to be Article V of the 1947 General Agreement on Tariffs and Trade (GATT). This requires States Parties to afford access to their ports for each others' vessels and goods in 'international transit', defined as passage across the port State's territory which 'is only a portion of a complete journey beginning and terminating beyond [its] frontier', where the said ports lie on 'the routes most convenient for international transit'. Paragraph (4) of the Article provides: 'All charges and regulations imposed by contracting parties on traffic in transit to or from the territories of other contracting parties shall be reasonable, having regard to the conditions of the traffic'. In so far as GATT will apply to vessels subjected to environmentally-differentiated dues in EU ports, therefore, this might be argued to place a 'reasonableness' requirement on the amounts levied. This is likely to be of particular significance to major entrepôt ports, like Rotterdam, Antwerp and Hamburg.

Under the LOSC, a coastal State's powers to prescribe and enforce environmental protection measures in respect of pollution in general from foreign ships are, absent 'special circumstances', somewhat limited in respect of its territorial sea and very limited beyond it (and in respect of ships in transit passage in certain straits used for international navigation). In respect of ship-source air pollution (which is governed by a different set of LOSC articles, 212 and 222, instead of 211 and 220), the coastal State is left greater regulatory discretion, but may not apply measures in waters lying beyond the territorial sea. MARPOL Reg. VI/11(6), when in force, will move the regime for ship-source air pollution much closer to that for pollution in general, but only as between Parties to MARPOL Annex VI. The law is very complex, and Appendix 4 deals with each of these three matters in turn. The following is a very generalised summary, looking instead at each maritime zone in turn. A full understanding can only be obtained from a thorough reading of paragraphs A4/39-94 and 110-120.

In the territorial sea (to which not all EU coastal States claim their full entitlement: see paragraph A4/53), in the interests of uniformity of regulation of international shipping, any coastal State laws and regulations that concern CDEM must give effect to 'generally accepted international rules and standards' (GAIRAS): Article 21(2) LOSC (albeit that this is less certain in the case of emissions to air than marine pollution in general). Otherwise national standards, including emissions standards, are permissible. 'GAIRAS' is undefined, and its meaning the subject of much debate. The preferred (academic) interpretation 'is that this qualification is met when the criteria "widespread and representative participation in the [,in this case, MARPOL] convention, provided it included that of States whose interests were specifically affected", are fulfilled': Molenaar, 1998, p. 183. In the case of pollution in general, but not air pollution (except as between Parties to MARPOL Annex VI, when it comes into force), these MARPOL-based 'GAIRAS' are mandatory even for flag States not Parties to MARPOL, because of the 'indirectly binding effect' of the rules of reference to them in the LOSC (by consenting to be bound by the LOSC, the State consents to be bound by those standards too), or arguably even as a matter of customary international law. See paragraphs A4/39-45, 64 and 113. The coastal State cannot, it appears, adopt national standards where no such GAIRAS yet exist, and, MARPOL Annex VI not yet being in force, none appear to in respect of ship emissions. See paragraphs A4/26-27, 48 and 52. It follows that the EC must argue that a requirement applied to territorial seas to use only bunkers with a certain sulphur content is an 'emission' rather than a CDEM standard. Such an argument would be controversial, but, in our opinion, sustainable. See paragraphs A4/69-75.

As to enforcement of territorial sea standards, Article 220(1) LOSC permits the coastal State to enforce in port its laws and regulations on pollution in general, subject to certain procedural safeguards. Articles 27 and 220(2) permit it to carry out enforcement measures in the territorial sea too, as long as it does not thereby hamper innocent passage, but States rarely do. Article 222 on air pollution is much less specific as to how a coastal State should carry out enforcement and appears to leave them a broad discretion. Indeed, the vague formulae in both air pollution articles are such that, far from representing facultative maximum standards for coastal States (as the provisions on pollution in general do), they provide only a (in the words of Molenaar, 1998, p. 501) '"mildly" mandatory' minimum standard, and give little guidance on the minimum standard to be aimed at. But it does not follow that prescription and at-sea enforcement opportunities are greater in respect of air pollution than pollution in general; in particular, they are clearly limited to the territorial sea; Article 21(2) appears to prevail over Article 212; and MARPOL Reg. VI/11(6) will bring the air pollution regime much closer to that for pollution in general.

In the Straits of Dover, the Strait of Gibraltar, the Danish Straits and several other important European straits, the coastal State's position is even weaker, in respect of foreign ships in transit passage. While it is clear that the coastal state can at least prescribe MARPOL <u>oil pollution</u> standards for vessels in transit passage, it is far from clear that they may similarly prescribe air pollution standards. When in force, MARPOL Reg. VI/11(6)'s effect, as between Parties to MARPOL Annex VI, is likely to be limited to extending the broad duty of vessels in transit passage to comply with relevant oil pollution standards to air pollution too. This will still leave a dearth of enforcement powers. While Article 220(1) would appear to permit in-port enforcement, it is highly unlikely that the Article 233 pre-condition to at-sea enforcement measures of a threat of or occurrence of major pollution damage would ever be satisfied in an air pollution case.

The vast majority of EU waters between 12 and 200 nautical miles from the coastal baselines, with the notable exception of Mediterranean waters, is now or is likely soon to be subject, through claims to 200 mile zones, to the environmental protection jurisdiction of EU Member States (as EEZs or otherwise). While a State may prescribe laws and regulations for the prevention, reduction and control of pollution from vessels in general, conforming to and giving effect to GAIRAS (Article 211(5)), it has no such power in respect of ship-source air pollution. In any event, at-sea enforcement by the coastal State is closely circumscribed, by Article 220(3), (5) and (6). In-port enforcement, under Article 220(1) is much to be preferred. The prospects for establishing 'Article 211(6) LOSC special areas' in parts of Member States' jurisdictional waters, in order to apply higher air pollution standards, are poor. Any effort at arguing that certain EU waters are a 'special circumstance' deserving enhanced protection should be directed towards the adoption of further SOxECAs under MARPOL Annex VI.

Indeed, while the LOSC should not be seen as a static instrument, including in respect of the navigation/environment balance it establishes, there appear to be little scope for a broader interpretation than that given above, whether based on 'special circumstance' arguments or teleological reasoning. See paragraphs A4/95-109.

3.3 Regulatory Treaties

The disappointingly low SO_x and NO_x standards of MARPOL Annex VI and the non-jurisdictional aspects of its compliance mechanisms are described in paragraphs A4/210-24. The most significant paragraphs are those which suggest the likely attitudes of stakeholders to any EC legislation in the field and in particular the pivotal role of the oil companies (A4/223-24). The 1979 UNECE Long-Range Transboundary Air Pollution Convention and its relevant Protocols are discussed in paragraphs A4/225-242. They involve few constraints upon State Parties relevant to ship-source pollution in EU waters. The main contribution arises from the Second Sulphur Protocol. Seven non-EC European States Parties to this, as well as Canada, are obliged, in addition to thirteen EC Member States Parties to the Protocol (Belgium and Portugal are not Parties), to control, in accordance with the Protocol's provisions, emissions from vessels flying their flags (and engaged in international trade) that occur while they are in the territorial waters, including the ports, of any mainland European coastal State Member of the UNECE. The various 'regional seas' and other sub-regional environmental agreements of potential relevance to ship-source air pollution arising in EU waters in practice have little significance: see paragraphs A4/243-53. The same appears to be true of the European Energy Charter Treaty: see paragraph A4/254.

The UN's 1992 Framework Convention on Climate Change (FCCC) and its 1997 Kyoto Protocol are, however, of great potential significance, given the synergies between NO_x emissions and enhanced global warming. The Commission ought, therefore, to attempt to take into account the indirect effect of future measures to combat climate change, including any arising from the current IMO/FCCC consideration of shipping's contribution, on an EC ship emissions regime for SO_2 and NOx: see paragraphs A4/255-68. International Trade Law is also binding on the EC and its Member States. Article V of the GATT has been mentioned above. The General Agreement on Trade in Services is also of potential relevance, in respect of the potential for environmentally-differentiated shipping dues to constitute a restraint on trade in services and/or to need to be accompanied by positive financial incentives (subsidies). To date, however, it has only loosely applied to shipping services, and there are very few individual country commitments in the area. This might, of course, change as a result of the new Seattle Round of negotiations. It is nevertheless, sensible during the preparation of an EC ship emissions proposal to observe the general trade law principles of no-more-favoured nation and national treatment and to bear in mind GATT/GATS limits on subsidies to domestic industry.

3.4 EC Law

As far as EC Law is concerned, there is little doubt that the Community has both internal and external competence to act in respect of either of the two instruments under consideration, the real question being the degree to which it should do so. The main difference between the regulatory and economic instrument approaches derives from the sensitivity of Member States in fiscal matters. This is reflected in the different voting procedures for the adoption of EC measures: regulatory measures may be adopted through the co-decision procedure, while the adoption of economic instruments requires unanimity in the Council (see paragraphs A4/309, 314, 320, 347, 352, 382 and 402). The greater difficulty of securing economic instruments legislation is, however, largely off-set by their economic and environmental advantages and the Commission's desire to employ a diverse array of instruments to environmental protection. This effect is further strengthened by *Bic Benelux SA v Belgium* (see paragraph A4/347).

Various EC law principles have relevance. It is arguable, for example, that an economic instruments approach is more consistent with the central 'integrationist' and sustainable development principles of EC environmental policy than a regulatory approach: see paragraphs A4/302-07. Of the remaining environmental principles, those set out in Article 174 of the Treaty (the principles of: a 'high level of environmental protection'; prevention and precaution; that environmental damage should as a priority be rectified at source; and the "polluter pays") have little potential impact on a ship emissions regime of either kind (see paragraphs A4/323-334).

On the other hand, the broader principles of subsidiarity and proportionality, while very unlikely to lead to successful <u>legal</u> challenges to a ship emissions regime (see paragraphs A4/353-61), are likely to have significant political impacts. These impacts will be many (see paragraphs A4/335-352). The Commission will, for example, have regard to these principles, in accordance with its procedures, and indeed almost as a matter of course, when preparing a Proposal for a Directive, and will fulfil the procedural requirements of the Protocol to the Treaty on their application. It will also, almost certainly, prefer a Directive to a Regulation. Most important, however, is the fact that the subsidiarity principle 'is leading to a form of condominium being established in the environmental field with tasks being increasingly organised along functional rather than territorial lines' (Chalmers, 1999, pp. 678-79). As far as environmental instruments are concerned, this has both a negative and a positive impact. As to the negative, the 'development of subsidiarity' during the 1990s, Chalmers suggests (*ibid.*), 'was above all a drive to prevent EC institutions from acquiring increased <u>symbolic capital</u> (emphasis added)' through a growth, not in legislative output, but in the <u>functions of government</u>. 'Increasingly, national administrations are therefore ringfencing and asserting control over certain forms of regulation. There was thus strong opposition… to a tax on CO_2 emissions, from not just economic interests but also administrative ones'. The Member States sensitivity about Community taxes (or charges) strengthens the hand of opponents of any Commission proposal to establish an EC system of environmentally-differentiated shipping dues; they already have the advantage of the requirement of unanimity for the adoption of such measures, and they might well, in addition, phrase their opposition largely in terms of subsidiarity (see paragraphs A4/352 and 382). On the other, hand, the development of shared responsibility in environmental matters has made it necessary to develop principles to co-ordinate it, which might be termed the 'shared responsibility' and 'minimum harmonisation' principles. These arguably redefine the 'subsidiarity/proportionality' question (in respect of both regulation and an economic instruments approach) from 'should and how should the EC intervene?'

to 'to what level of detail should EC intervention extend?' See paragraphs A4/352 and 361.

If a purely regulatory approach were taken at EC level to the control of ship emissions, there would be a choice, broadly speaking, between two main legal bases, Article 95 (ex 100a), under the Approximation of Laws Title, and Article 175 (ex 130s), under the Environment Title, of the Treaty. While the adoption procedures are the same (co-decision), the latter is to be preferred because of its greater flexibility, particularly in terms of Member States' ability to maintain or introduce higher national standards to meet local needs. Use of Article 175 as the legal base of an EC ship emissions measure is far the more consistent with this and the 'shared responsibility' and 'minimum harmonisation' principles. See paragraphs A4/316-17, 308-21 and 362-71.

If, on the other hand, emphasis were to be placed by the EC on economic instruments, the choice would be slightly different: between Article 94 and Article 175. In addition, the legal base would arguably also need to incorporate Article 93 (ex 99), to the extent that the instrument in question were to create an indirect tax. Adoption of this legislation would require unanimity, employing the 'consultation procedure'. Again Article 175 is to be preferred, if possible. See the same paragraphs.

Paragraphs A4/372-419 examine the EC law concerning the use of financial disincentives (taxes and charges) and disincentives (subsidies) for environmental protection purposes, both at the EC and the Member State level, in terms of their prospective relevance to an EC system of environmentally-differentiated shipping dues.

The analysis suggests that justified caution has been displayed by the EC Institutions with respect to themselves establishing financial disincentives at EC level, given the Member State sensitivity referred to above, and the need to place such measures in respect of shipping within the developing broader framework envisaged by the White Paper on *Fair Payment for Infrastructure Use* (paragraphs A4/380-84 and 388-92).

The Cohesion Fund is by far the most significant potential source of EC financial incentives in support of an EC system of environmentally-differentiated shipping dues, particularly in Spanish, and to a lesser extent Portuguese and Greek, ports (see paragraphs A4/393-400). The analysis also notes that the prospect of removing (by unanimity in the Council) marine bunker fuels' present exemption from minimum EC excise duty rates should be borne in mind (paragraph A4/401).

Each Member State is free to establish its own tax system, including in respect of environmental taxes and charges, such as environmentally-differentiated shipping dues, until harmonisation is realised. Indeed, given the paucity of Community tax harmonisation measures, most existing environmental taxes and charges are established at the national level, including in the shipping field (see Appendix 3). Given, moreover, the Commission's attachment to the 'shared responsibility' and 'minimum harmonisation' principles, existing and any future national environmentally-differentiated shipping dues systems are likely to operate over and above any minimum EC system to be established. The Study adds little to the Commission's analysis of the legal position set out in *Environmental Taxes and Charges in the Internal Market.* See paragraphs A4/402-07.

As, moreover, predominant responsibility for financing the Community environmental policy remains with the Member States, most environmental subsidies still come from them. According to Article 92 (now 87) of the Treaty, any aid granted by a Member State which distorts or threatens to distort competition is incompatible with the common market. As a general rule, an aid element contained in a levy system cannot be authorised by the Commission if other provisions of the Treaty are being infringed. Several might apply. Where a 100% refund of a tax or charge to a domestic undertaking within the same industry is intended solely to provide it with financial support for its specific advantage, the refund will be considered a customs duty, to which Article 25 (ex 12) applies. Where such a refund is less than 100%, it is likely to be dealt with under Article 90 (ex 95), as well perhaps as Article 87 (ex 92). Where the revenues are paid into the general treasury, however, thus breaking the link between it and the aid given the industry, it fall to be dealt with under Article 87 alone. The latter is the most likely to arise in this instance.

Articles 87-89 (ex 92-94) establish a special mechanism whereby the Commission must be notified of State aids in order to assess their compatibility with Community rules. It enjoys considerable discretion with regard to the Article 87(3) list of types of aid that may nevertheless be considered to be compatible with the common market. The list includes two categories of particular relevance, and the Council may even, acting by a qualified majority on a proposal from the Commission, extend the list to non-listed categories of aid (Article 87(3)(e)). Given the Court's reluctance to overturn Commission decisions on state aids, the Commission guidelines on state aids are very important to an assessment of the likely acceptability of any grants made in support of an EC ship emissions regime. This is so notwithstanding that the Commission is prepared, on appropriate occasions, to authorise individual provisions of state aid that strictly fall outside the terms of those guidelines. When considering doing so in this instance, however, it should bear in mind the possible international trade law constraints discussed above. The key guidelines in this context are the *Community Guidelines on State Aid for Environmental Protection*. Further guidance might also emerge soon in a set of guidelines on the financing of port infrastructure, which might effect significant changes. The main hurdle for any kind of aid to jump in order to fall within any of the guidelines is that it must facilitate adjustment to new standards. It should also, in principle, be limited to investment aid, although the Commission exceptionally permits operating aid in certain well-defined circumstances, including in respect of 'relief from environmental taxes' where this is necessary to offset losses in competitiveness, particularly at international level. Investment aid to help ports or ship owners or operators adapt to new mandatory standards on ships' emissions, and involving adaptation of ships' equipment to meet these, can generally be authorised up to the level of 15% gross of the eligible costs. Aid for investment that allows significantly higher levels than these new standards to be attained (for example, under an environmentally-differentiated shipping dues scheme) may be authorised up to the level of 30% gross of the eligible costs (and more for small or medium-sized enterprises). See paragraphs A4/ 408-18.

Consideration of the Gordian knot of uncertain and conflicting jurisprudence on the Community's external competence in this area appears to put a premium on the Commission's emphasising that competence is mixed and will be exercised in view of the shared responsibility and minimum harmonisation principles (see paragraphs A4/420-25).

Measures taken in port or with regard to ships under an EC ship emissions regime must be framed so as not to infringe EC competition policy. If, for example, a Member State authority were to place the provision of an environmentally-differentiated port dues service in the hands of restricted categories of service providers, it is likely that that policy would be infringed if the services were considered as services offered on the market as economic activities of a commercial or industrial nature. In our opinion, however, they would be more likely to be understood to be services conducted in the exercise of official authority, and for a public purpose exempt from EC competition rules: *Porto di Genova* (1997). See paragraphs A4/428-30.

In addition, the tendering processes of public authorities or undertakings (or of other bodies operating under special exclusive rights granted by a Member State competent authority) which are aimed at placing the provision of an environmentally-differentiated port dues service in the hands of a competent service provider would potentially fall within the ambit of EC public procurement policy. It appears most likely that Directive 93/38 (Coordinating the Procurement Procedures of Entities Operating in the Water, Energy, Transport and Telecommunications Sectors) will apply, at least in respect of tenders put out by the public bodies in the maritime field listed in Annex IX to the Directive. See paragraphs A4/431-32.

3.5 National Laws

Member States' claims, legislation and attitudes towards marine environmental protection are briefly examined (in paragraphs A4/433-36), for two reasons: (i) they are relevant to the issue of the degree to which State practice should influence the Commission's view of the applicable (global) international law of the sea; and (ii) they are indicative of the furthest that individual Member States are likely to be prepared to go or, conversely, of the lengths to which they might be prepared to 'push the limits' of that law, either *erga omnes* or *inter se*.

While, for example, several EC/EEA coastal States have marine pollution legislation prescribing standards for foreign ships in their internal waters (or ports), territorial seas and, in some cases, jurisdictional waters, fewer provide for at-sea enforcement, and most exhibit a strong preference for in-port enforcement. The UK in particular opposes any other option (see paragraph A4/112 above), and, consistently with this, its 1996 Pollution Regulations do not provide for enforcement at sea; there thus seems to be little point in the Commission seeking to change its mind, where in-port enforcement measures are likely, as we argue they are, to be adequate.

No Member State marine pollution legislation applying to its territorial sea or jurisdictional waters to date appears to specifically address ship-source air pollution, but much of it is general enough to cover, or be easily extended to, it as well as polluting discharges. A brief outline is given in Appendix 4, with emphasis on the several States that appear to have claimed broad powers. Noteworthy is that a number of Member States have, as they are entitled to do, imposed national discharge standards higher than MARPOL standards in their territorial seas, and that few have taken powers also to control (contrary to the LOSC) CDEM matters. Also noteworthy is the general effort, with few exceptions, to follow the LOSC quite closely, except for several cases of neglect to draw the distinction made in the LOSC between enforcement powers in the territorial sea and those in the EEZ. It is telling that even sophisticated European States have found the fine distinctions in the LOSC perhaps too complex to bother with.

3.6 Compliance Aspects

In relation to a regulatory approach, the main enforcement mechanism is likely to be port State control (PSC), to which end the PSC Directive would probably need to be amended. Technical difficulties require resolution, such as the possible need to develop a system for the calculation of the sulphur content of bunker fuels used in the EU waters to be covered by the Directive in parallel with the global system being developed under the IMO Sulphur Content Guidelines. In addition, it is very difficult to see how SOxECA requirements can be effectively policed and enforced either in port or at sea, except in respect of ships that operate more or less exclusively within a single SOxECA, or two or more adjacent SOxECAs, or of ships that can be clearly demonstrated to operate only on low-sulphur (1.5%) fuel. Absent a sufficiently fail-safe global system of bunker delivery notes which (together with bunker receipts, both backed up ultimately by the sulphur content calculation system) constitute reliable evidence of the quantities and sulphur content of bunker fuel taken on board and/or of reliable ships' logging of where and when change-over procedures between high- and low-sulphur fuels kept in different tanks take place, it will be nigh on impossible to determine via PSC, or even at-sea observation (see paragraph A4/69), whether or not a vessel is in compliance. The reality is that the global bunker delivery note system envisaged under MARPOL Annex VI has yet to be developed and put into operation (see paragraph A4/217), and that ships' logs or record books cannot always be relied upon, even supposing they have been completed in timely fashion. One legal device to ameliorate the latter problem is to require the correct completion of logs and record books as a condition of port entry and, indeed, to treat this as a continuing offence regardless of when and where the duty to complete them arises. See paragraphs A4/437-46.

Economic instruments applied to ships' emissions will not raise enforcement issues as such, nor indeed issues of compliance with any set standard. Rather they will exhort and encourage, through manipulation of the price mechanism, observance of best, or at least better, practice by the owners or operators of ships calling at EU ports. By definition, one will not obtain the same uptake by all operators. Nevertheless, it can be said that industry/public acceptance of environmentally-differentiated dues would be enhanced by making them revenue-neutral rather than revenue-raising. In relation to ports' willingness to co-operate in implementing economic instruments it can be added that, while oil companies generally have long experience of acting as tax-collectors for government and sophisticated accounting infrastructures, port authorities in general do not. This suggests that a 'green' fuel charge on bunkers taken on in European ports might be a more easily administered measure than a system of environmentally-differentiated dues levied in ports. Port authorities, which already feel themselves under heavy legislative and environmental pressures, will be reluctant, if asked, to take on the role of 'tax collector (or charge administrator)' for government. It would, at the very least, appear reasonable to permit port authorities to recover their administrative costs, and nothing in EC law prevents this. In addition, ports should not have to subsidise the system. See paragraphs A4/447-49.

Finally, the concluding paragraphs of Appendix 4 emphasise the importance of the oil industry as a stakeholder in this field and suggest that both extension of an EC instrument, of either type, to 'non-Convention' vessels and mandatory 'cold-ironing' of ships in port are legal.

4. OPTIONS FOR REDUCING SHIP ATMOSPHERIC EMISSIONS

4.1 General Policy Areas

An outline of possible strategy types for the control of ships' emission of SO_2 and NO_x is given below.

	Policy	I S – SO_2	II N - NO_x
Regulation			
A	Control pollutant at point of sale	Sulphur content of marine fuels sold in Europe	Not applicable
B	Control pollutant in fuel consumed	Sulphur content of marine fuels used in EU waters	Not applicable
C	Control stack emissions of ships	Prescribed emission rate for S or SO_2 in European waters	Prescribed emission rate for N or NO_x in European waters
Economic Incentive			
D	Incentive based on fuel purchased	Recognised bunker receipts and testing	Not applicable
E	Incentive based on bunkers used and on-board	Consumption records	Not applicable
F	Incentive based on certified emission performance	Exhaust performance certification / monitoring	Exhaust performance certification / monitoring

The policy instruments specified in the Technical Annex for this study are highlighted in the above table. In summary:

Environmentally differentiated dues

- Sulphur content of bunker fuel oil: **DI, EI**
- NO_x emission limits: **FII**

Regulation

- Regulated sulphur content in marine fuels: **AI, BI**

By contrast, MARPOL Annex VI, relates to the above table as follows:

NO_x (Regulation 13)

- Restriction on exhaust emission flux: **CII**

SO_x (Regulation 14)

- General: **BI**
- SO_x Emission Control Area: **BI** or **CI**

The Swedish environmentally differentiated dues system also deals with NO_x and sulphur, through emission and fuel quality control, respectively, i.e. through policy routes **FII** and **EI**.

Thus in terms of the foregoing table:

	Policy	I $S - SO_2$	II $N - NO_x$
Regulation			
A	Control pollutant at point of sale	This study	
B	Control pollutant in fuel consumed	This study; MARPOL	
C	Control stack emissions of ships	MARPOL (SOxECA)	MARPOL
Economic Incentive			
D	Incentive based on fuel purchased	This study; Swedish system	
E	Incentive based on bunkers used and on-board	This study; Swedish system	
F	Incentive based on certified emission performance		This study; Swedish system

It is unreasonable to reject policy area FI out of hand, since the regulatory equivalent (CI) exits in MARPOL, the equivalent exists for NO_x and a similar economic instrument could be devised.

4.2 Analysis Approach

For each of the foregoing policy principles there are a number of sub-options that relate to the intended extent of the emission control and the resulting environmental benefit. Specifically the Commission requested that policies using sulphur levels in fuel of 1.5%, 1.0% and 0.5% be considered and NO_x emission rates of 12g/kWh, 7g/kWh and 2g/kWh be assessed. Equally, of course, sliding scales of abatement levels are feasible.

The main quantitative analysis of these options is described in Appendix 7. Economic models of the main options were built that bring together the main technical, environmental and legal findings.

A large number of interrelated factors must be brought together to make a quantified estimate of the effectiveness of the different policy options and so predict the resultant abatement of emissions and environmental benefit. These include, *inter alia*:

- the distribution of ships (by type) that operate in European waters
- the distribution, within each ship type, of size (grt); installed (and typical operating) power; power plant type (slow, medium, high speed and steam)
- the distribution of each power plant type by emission (i.e. extent of NO_x emission relative to proposed standards)
- each power plant by fuel consumption efficiency
- the geographical pattern of purchase of bunkers and the variation in their sulphur content
- the price of bunkers in different locations, the variation of price with quality

and the prediction of bunker prices in the future (under changed demand scenarios)
- each ship by age and therefore potential for investment and available depreciation period
- cost of abatement of NO_x by different technical methods and by degree of reduction required (also in future circumstances of changed demand)
- each ship type by geography of use (how frequent a visitor to Europe)
- each ship type by voyage length / fuel burned (how much and where within European waters)
- each ship type by utilisation (hours per year) and by number of visits to EU ports
- the distribution of ship owners / managers / charterers by attitude and culture to the extent that it impinges on compliance with regulation or adoption of an incentive (attractiveness of incentive by different standards of judgement of return on investment)
- the attitude and actions of Member States in support of EU policies, their commitment to enforcement and the relationship with their national and private ports

Clearly we have an imperfect knowledge of most of these factors and certain assumptions have inevitably been made. These are described more fully in Appendix 7, which in turn draws on information from all the other appendices to populate the models and derive its conclusions. The conclusions are discussed next in Chapter 5.

5. ANALYSIS OF POLICY OPTIONS

5.1 Baseline Data

In Chapter 2 (Tables 2.3 and 2.4) a number of estimates of shipping emissions based on historical data are given. In Appendix 7 these estimates are projected forward to a baseline year of around 2001 and the results are summarised in the table below. It should be noted that policies to abate emissions are discussed in this chapter in relation to this base year. It should not be taken to mean, however, that these policies could necessarily take effect from such a date.

Table 5.1 Summary of baseline data for policy assessment

MARINE AREA	FUEL CONSUMED (KT)	SO_x (KT)	NO_x (KT)
Area 1: Baltic Sea	5,301	232	365
Area 2: North-west European Waters	14,376	867	990
Area 3: Mediterranean Sea	7,547	455	520
Area 4: NE Atlantic	6,290	379	433
Sub-total European waters	33,514	1,934	2,308
World	179,700	10,541	12,574

It is estimated that approximately 30,000 different ships over 250grt operate in European waters, which represents just over 50% of the world total. For such a large proportion of world tonnage it has been assumed that the distribution of ship type and sizes is similar to that of the world fleet.

Table 5.2 Breakdown of ships > 250 grt active in European waters

SHIP TYPE	SHIPS ACTIVE IN EURO. WATERS	AVG. GRT PER VESSEL (T)	TOTAL GRT ('000 T)	ANNUAL FUEL CONSUMPTION IN ALL WATERS ('000 T)	ANNUAL FUEL CONSUMPTION IN EUROPEAN WATERS ('000 T)	ANNUAL FUEL CONSUMPTION IN EUROPEAN TERRITORIAL WATERS ('000 T)
Tankers	3,518	26,861	94,494	18,257	5,021	3,263
Dry bulk	2,971	27,610	82,017	15,848	4,358	2,833
Container	1,236	22,489	27,791	15,955	4,388	2,852
Ro-Ro	743	17,991	13,365	10,022	9,020	5,863
Cruise/Passenger	147	23,530	3,455	2,567	1,027	668
Other Cargo	5,823	5,690	33,132	26,660	6,665	4,332
Ships 250-1000grt	15,562	667	10,376	3,983	3,385	2,201
TOTAL	30,000	8,821	264,629	93,292	33,863	22,011

It should be noted that the numbers quoted for the same statistic are not always exactly the same. For example in the tables above, the total fuel consumed in EU waters varies slightly. This is due to their different origins. In the former the COADS data on shipping activity (Appendix 1) yields a proportion of world totals for the sea areas under consideration, whereas in the latter specific fuel consumption for different ship types, installed power and the assumed distribution of ships is used together with an annual utilisation constrained to generate an appropriate total fuel consumption for these ships in all waters. Appendix 7 explains the derivation of the figures in more detail, but the essential principle is the existence of a reasonable and **consistent** set of assumptions that provide crosschecks for the main integrated and average quantities.

Appendix 7 further describes consistent data sets that have been derived for total megawatt hours and the distribution of power consumed at different levels of NO_x emission. On the basis of known total fuel consumption and total emissions of NO_x (Table 5.1), power consumed links the two such that an average NO_x emission rate can be calculated. An average across all the "EU active" ships of 13.5 g/kWh has been deduced, with a distribution of certain characteristics.

This is a calculated figure driven by a combination of overall fuel consumption and total NO_x emission. It is somewhat less than the average figure used by Lloyds Register (see for example Appendix 1) - effectively between 14 and 16 g/kWh depending on the split between slow and medium speed engines – which emerged from their measurement activities in the early 1990's.

5.2 Regulation of the sulphur content of fuel sold in Europe (AI)

This option concerns a potential set of national regulations to be implemented by individual EU Member States that would prohibit the sale of marine bunker fuels with a sulphur content above a specified level; the sulphur levels to be considered being 1.5%, 1.0% and 0.5%. These levels compare with the current MARPOL Annex VI global cap of 4.5% and a maximum sulphur content level of 1.5% in the SO_x Emission Control Areas (SOxECAs). By way of further comparison, **non-marine** heavy fuel oils will be restricted to 1% sulphur content by 2003 (Directive 99/32/EC – see para A4:318) and gas oils, including marine gas oils, must contain less than 0.2% sulphur by July 2000 and less than 0.1% by 2008.

Whereas the new EC liquid fuels regime will apply to consumption[2], it should be recognised that the option considered here relates to sales only and would not directly regulate the consumption of high-S fuels by ships in European waters.

A model was constructed to assess the likely effect of this policy (App.7) and the results are summarised in Table 5.3. A more comprehensive tabulation is provided in Appendix 7, Table 7.5. The appendix describes the basis of the calculations and the assumptions required to operate the model. In summary, these are:

- an increasing price premium for low sulphur fuel compared with present HFO bunkers (see App. 5 section 8)
- a reduction in sales by EU countries, as more imported fuel is carried into EU waters and less EU-origin fuel is carried out (see A5:2 and A7:2.2.3)
- a modest reduction in fuel consumption associated with the slightly higher specific energy of low-S fuels
- that all Member States will implement an EU requirement giving effect to this

[2] To fully implement the Directive, a Member State must: prohibit the use within its territory of Heavy Fuel Oil and Gas Oil having a sulphur content higher than the specified levels; establish a system of fuel sampling to ensure compliance; issue permits to plants; and, establish a system of penalties for breaches of the SO_x limits.

policy, such that there is uniformity across Europe in the *base* year

Table 5.3 Potential effect in all European waters of regulations for sulphur content of marine fuels sold in Europe

	BASELINE 'BUSINESS AS USUAL'	OPTION AIA (1.5%S)	NET CHANGE	OPTION AIB (1.0%S)	NET CHANGE	OPTION AIC (0.5% S)	NET CHANGE
Bunker sales by EU Member States ('000 tonnes)	40,589	28,412	-12,177	22,324	-18,265	16,236	-24,353
Marine bunkers consumed in 'European waters' ('000 tonnes)	33,514	33,201	313	33,181	333	33,204	310
'Imports' as a % of consumption	17.9%	23.0%	5.1%	39.4%	21.5%	56.0%	38.1%
Average S in fuel consumed in European waters	2.9%	1.8%	-1.1%	1.8%	-1.1%	1.9%	-1.0%
Total SO_x emissions from European waters ('000 tonnes)	1,934	1,182	-752	1,173	-761	1,260	-674
Reduction in SO_x emissions from European waters			-38.9%		-39.4%		-34.8%
Fuel costs for ships operating in European waters (US$ million)	$4,168	$4,846	$677	$4,862	$694	$5,059	$891
Cost per tonne of reduced SO_x emissions from European waters ($US)			$901		$911		$1,322

The results above reflect the inevitable trend of ships resisting the purchase of low sulphur bunkers to an increasing extent as the low sulphur fuel price increases. In fact the table shows a diminishing return in the abatement of SO_2 emissions. All that can be achieved is achieved at the 1% S level. Lower sulphur levels are defeated by the rapidly increasing cost.

In broad terms it is predicted that a regulation of sulphur content would yield up to a 40% reduction in SO_2 emissions from shipping in the defined European waters at a cost of in excess of $900 per tonne of abated emission. The additional cost to shipping would be around $700 million per annum. [Note that estimates of future prices of fuel vary between analysts – see A5.8]

"Captive" European shipping would be the primary user and to that extent the policy might favour emission reductions in near-shore areas. Otherwise, however, the policy suffers from not being targeted in geographical terms and from being likely to produce significant distortions in the fuel import – export sales balance.

An approximate "best" result is estimated to be as follows:

Table 5.4 Estimated maximum effect of regulation of sulphur content of fuels sold in Europe.

MARINE AREA	BASELINE SO_x EMISSIONS	SO_x EMISSIONS AT AN AVERAGE OF 1.75%	EMISSION REDUCTION (KT)
Area 1: Baltic Sea	232	183	71
Area 2: NW European waters	867	495	359
Area 3: Mediterranean Sea	455	260	188
Area 4: NE Atlantic	379	217	157
Total	1,934	1,154	776

This result can be achieved with a 1% sulphur content in heavy fuel oil regulation (option AIb) and such a regulation would complement the requirements of the Liquid Fuels Directive. Indeed the system could adopt some of the sampling and record keeping requirements planned for use on land. Certainly the legal analysis (Chapter 3 and Appendix 4) does not suggest any difficulties in introducing such a regulation, and the technical issues for shipping would not be great (App.5 and 7), especially as there would be no requirement to segregate bunkers of different quality. Nonetheless there would be profound implications for the refining and bunker supply market, and other methods (see below) are likely to prove superior in achieving the environmental objectives.

5.3 Regulation of the sulphur content of fuel consumed in Europe (BI)

The second regulatory option considered for SO_2 is that of prescribing limits on the sulphur content of the fuel burned by ships in European waters. In relation to such a policy three key considerations are: the legal constraints; enforceability; and the potential effectiveness in reducing emissions.

The legal considerations are complex as has been discussed in Chapter 3 and in fuller detail in Appendix 4. The legal arguments guide the analysis along the following lines (taken from Chapter 3, section 3.2):

These possible restrictions notwithstanding, there is a strong case to suggest that, given the difficulties surrounding the prescription of standards for off-shore waters, described below, the EC should consider prescribing only in-port measures, or at the most should (given that the majority of damaging ship emissions occur close to the coast) prescribe in addition only emissions standards in the territorial sea (see esp. paragraph A4/207). In any event, the reluctance of Member States (particularly the UK) to take off-shore enforcement measures, even in the territorial sea, suggests that all relevant measures (whether in-port or off-shore) should in general be enforced in port (see esp. paragraph A4/208).

The reference to *emissions standards* refers to the distinction between these and CDEM standards. The latter are "construction, design, equipment and manning" standards that in effect travel with the ship. It is observed in Chapter 3 that: *In-port measures in particular that have the practical effect of imposing requirements above international standards that the vessel must comply with throughout its voyage in order to comply in port are likely to be hotly disputed.*

Chapter 3 concludes that the argument for sulphur-content-in-fuel restrictions being regarded as an emission rather than a CDEM standard is likely to be sustainable and certainly technically and operationally (Appendix 5) it is possible to utilise a prescribed fuel for only part of a voyage.

For the purposes of quantifying the effect of this policy option, judgements on compliance have been required. One clear conclusion (Appendix 7) is that compliance may be expected to decrease as distance from shore increases. This is true for both practical as well as the legal reasons above. In addition, compliance has been assumed to decrease as the level of avoided costs increases. Thus, for example, in considering likely levels of compliance for various maximum S levels, it is assumed that, all else being equal, a 0.5% maximum S regulation will elicit a lower level of compliance than a less costly 1.5% regulation. The resulting assessment is shown in Table 5.5, which is an abbreviation of A7:Table 7.7.

Table 5.5: Potential effect in all European waters of regulations for sulphur content of marine fuels consumed.

	Business as usual	Option B1a (1.5%S)	Change	Option B1b (1.0%S)	Change	Option B1c (0.5% S)	Change
Fuel consumption at prescribed level (%)							
Ports	14%	100%		95%		90%	
Territorial	9%	75%		70%		65%	
EEZ excluding territorial	6%	25%		20%		15%	
Outside EEZ	4%	10%		6%		4%	
Consumption of low-S bunkers (tonnes)	2,984	20,799	17,815	19,131	16,147	17,542	14,558
Consumption of high-S bunkers (tonnes)	30,530	12,486	(18,044)	14,110	(16,420)	15,668	(14,863)
SO_2 Emissions							
Ports	462	229	(233)	175	(286)	126	(336)
Territorial	774	487	(287)	427	(347)	376	(397)
EEZ excluding territorial	496	444	(52)	446	(51)	454	(42)
Outside EEZ	202	195	(7)	199	(3)	201	(1)
Total	1,934	1,355	(579)	1,247	(687)	1,157	(777)
Average S levels in fuel consumed	2.9%	2.0%	-0.8%	1.9%	-1.0%	1.7%	-1.1%
Reduction in SO_2 emissions			-29.9%		-35.5%		-40.2%
Costs							
Total fuel expenses of ships operating in European waters ($m)	$4,168	$4,699	$530	$4,803	$634	$5,199	$1,030
Cost per tonne of reduced S emissions over European waters ($US)			$916		$922		$1,327

In the table above the first section relates to adoption of low S fuels by ships when operating in different waters. "Adoption" is a matter of straightforward compliance with legislation and continuing use of low S fuel beyond regulatory requirements, either for reasons of operational convenience or other non-mandatory environmental policy. The extent of "adoption" shown in the table is a judgement based on: the increasing difficulties in legislating away from the coast; the ability to enforce only in port; the convenience for some short voyage near-shore operators to use one fuel type only; and the financial incentive to avoid using more high priced fuel than is necessary.

This analysis (see Appendix 7) yields a not dissimilar overall result to the first regulatory option (section 5.2 above). Emission reductions up to 40% can be expected at a cost to shipping of order $1 billion per annum. Once again the additional cost of regulating below 1% sulphur content is seen to be relatively high. Therefore, if a regulatory policy of this type were to be pursued, there would be good reason to establish the limit at 1%, in keeping with the new Liquid Fuels Directive (see section 5.2 above).

Subsequent to the performance of this analysis, MEPC 44(IMO) considered and adopted (March 2000), the proposal (MEPC 44/11/4/Add.1) that the North Sea be designated as a SO_x Emission Control Area. When this comes into force ships will be required to limit the sulphur content of bunkers to 1.5% (or equivalent emission). The MEPC proposal assumes a SO_x emission total of 439 kt in its defined North Sea area. This is approximately 23% of the EU emissions shown in Table 5.1 (only 16% if the LR(2000) figures are used for the Mediterranean). Using the analysis of Option B1a as a guide, the MARPOL Annex VI North Sea amendment (when in force), should produce the first 7% of the potential savings identified for this legislative option.

Table 5.6 illustrates (crudely) the potential environmental advantages of a well-chosen consumption regulation over a sales regulation. Consumption regulation requires the geographical area of application to be specified and thereby permits a measure of targeting on areas relative to their distance from shore. Indeed, as above in this section, there are strong legal arguments to suggest that the geographical application of such regulation may necessarily be limited in any case. The table below shows the result of considering the effect of a sales regulation to be geographically uniform, against the result from this more targeted consumption regulation approach.

Table 5.6: Distribution of SO_2 emissions reductions among geographic areas – Sales vs. consumption options based on 1% S in fuel regulations

Geographic Area	Baseline Emissions	Option AIB Emissions	% Reduction	Option BIB Emissions	% Reduction
Ports	462	279	39.6%	175	62.0%
Territorial sea	774	467	39.6%	427	44.8%
EEZ	496	300	39.6%	446	10.2%
Outside EEZ	202	122	39.6%	199	1.7%
Total	1,934	1,168	39.6%	1,247	35.5%

Whilst undoubtedly an over simplification, the table nonetheless illustrates the point that a lower overall emission reduction total may still be commensurate with a better geographical distribution of reduction and hence an improved environmental result (see Chapter 2 and Appendices 2 and 6).

Attempts to restrict emissions near ports in this way are somewhat reminiscent of the former ship practice of switching from HFO to diesel on the approach to port (see A5:4). The use of diesel, instead of HFO, for manoeuvring, re-starting engines and in advance of engine system maintenance, was common practice.

The combination of factors discussed in this section (legal, compliance, operational and environmental) suggests that a consumption **regulation** restricted only to ports and port approaches could be surprisingly effective, creating an environment for:

- Extended voluntary adoption of low S fuel by vessels that make frequent port calls
- Coupling with additional incentive based instruments or emission taxation that seeks to encourage more widespread adoption of low S fuel consumption (see also 5.10)

The latter point is discussed further below in the economic incentive sections.

In considering regulation relating to ships in the vicinity of ports, some regard should be taken of the parallel between ships in port and Large Combustion Plants (LCP), at least in terms of installed power.

From various large-port statistics (e.g. Rotterdam, Hong Kong) an average sea-going vessel remains in port for just over one day. Also taking average figures over significant numbers of ships (e.g. LR ’95 and ’99; also Appendix 5) an approximate ratio of 0.5kW per grt holds. At Rotterdam[3], therefore, 30,000 ships and 400 million grt translates into approximately 500MW of installed power being present on ships in the whole of the port on an average day. Of course, by no means all of this power is being utilised.

In terms of regulating LCP's an existing threshold is set at 50MW. On the basis of the above crude measure, therefore, twelve major ports[4] in Europe might be considered as "large", namely: Rotterdam; Antwerp, Marseilles; Hamburg; Le Havre; London; Amsterdam; Genoa; Wilhelmshaven; Dunkirk; Bremen and Zeebrugge. Clearly from the environmental perspective any policy aimed at tackling ships through their presence in port must ensure that the policy can work in the context of these major port complexes.

In the more general sense of power consumption throughout European waters, shipping is equivalent to something in the order of 390 50MW units running continuously throughout each day of the year.

5.4 Regulation of stack emissions of SO_2 in European waters (CI)

In principle the monitoring of sulphur content of fuels used is relatively straightforward. It is concerned with sampling, bunker receipts and correct ship's logs. In practice checking by authorities in port will be more difficult (see Chapter 3, 3.5 and paragraphs A4/437-46). The parallel on land is dealt with in Directive 99/32/EC (see 5.2 above), but clearly the mobile marine source poses many more difficulties than the static land-based industrial plant.

Regulation of stack emissions is clearly yet more problematical from the monitoring and verification standpoint and also, if not carefully handled, could meet opposition on the grounds of it being an equipment (CDEM) standard rather than an emission standard (see 5.3 above). For SO_2 of course, a particular emission level could be achieved either by burning low S fuel or by flue gas de-sulphurisation (FGD) or, indeed, by a combination of both.

MARPOL Annex VI is drafted to allow the alternative of 1.5% S in fuel or 6g/kWh of SO_2 emitted in a SOxECA. (The two numbers are simply linked by assuming an average specific fuel consumption by ships of 200g/kWh (see A5:3)).

There are good reasons to suggest that any consumption regulation should be phrased in the form of this alternative. Whilst FGD systems (A5:6.1) pose technical and environmental (disposal of waste products) problems today, it is nonetheless the case that exhaust streams can be scrubbed to low levels of emitted SO_2 and importantly, that the estimated "additional cost per tonne of fuel" may be significantly lower than the equivalent low S fuel premium, especially in a market of growing demand for such fuel. To discourage competition in the area of providing solutions for low SO_2 emissions would seem inherently counter-productive to the environmental cause.

It is our view, therefore, that any future regulation that restricts the S level in bunkers consumed so as to reduce atmospheric emissions of SO_2 should permit an alternative phrased in terms of the stack emission itself. Additionally, of course, it would be necessary to require that the system employed to control the stack

[3] Information from http://www.port.rotterdam.nl/
[4] Derived from 1998 throughput figures.

emission, did so in an environmentally acceptable fashion. The burden of demonstration that this is so should fall upon the "polluter" (the ship), but in turn the environmental impact assessment for the equipment used by the ship would, in practice, be provided by the equipment supplier.

5.5 Regulation of stack emissions of NO_x in European waters (CII)

This policy option is included for completeness though it falls outside the brief for this study, for reasons that will become clear below. It is in effect the mechanism embodied in MARPOL Annex VI (section 4.1 above) and acts to prescribe the emission levels of NO_x at all times of a ship's operation. Unlike SO_2, NO_x cannot be controlled via the fuel burned and the control solution lies mainly in the combustion process (Appendix 5). Thus NO_x control requires a CDEM standard, however much the requirement is expressed in terms of flux of pollutant (an emission prescription), just like that for SO_2 in option CI.

Chapter 3 and the more complete Appendix 4, describe the constraints upon coastal states in relation to seeking to impose CDEM requirements (see also 5.3 above) and the need to give effect to "generally accepted international rules and standards" (GAIRAS). However as MARPOL Annex VI is not yet in force, even its NO_x Code is not yet, it appears, a GAIRAS. Even if it were, the standards set for NO_x are very modest and offer little to the EU in environmental improvement terms (see discussion of option FII).

We conclude that it would be difficult to regulate NOx emissions in the territorial sea at levels higher than global standards. Although regulation in port would appear to be permissible, it would be likely to lead to protests because of its universal effect.

5.6 Economic Incentive based on fuel purchased (DI)

This option (DI) is the economic incentive equivalent of the regulatory option, AI. If ships can be induced to purchase low S fuel, then the possibility of reduced ship-source pollution exists.

As discussed in Appendix 3 economic incentive or compensation schemes already exist, or are being considered, to address issues of environmental protection. Some are nationally based (see A3:1,2,3 and 6); the SBT incentives are international and regional (A3:5) and the Green Award (A3:4) is an interesting and well established port initiative that covers ports in an increasing number of countries, though often thought of as being Dutch, due to its origins.

Economic incentive schemes are generally conceived to be port-based (see Chapter 3 and Appendices 3 and 4; also Kågeson 99[5] and Hader *et al* 00[6]). Whilst various mechanisms for their implementation exist, regard must also be paid to the constraints discussed at length in Chapter 3 and Appendix 4.

In this study economic models have been built to examine the expected operation of schemes of environmentally-differentiated shipping dues (A7:2.4 and A7:3.2). Economic theory suggests that in weighing either an operational decision or an investment requirement, each ship operator will seek to minimise costs and maximise

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[5] See App 3 bibliography
[6] Hader, Volk & Zachcial, ISL Report 2258, Bremen, Jan 2000: "*Incentive-based instruments for environmentally acceptable sea transportation*"

profits. In the present context, it therefore becomes essential to be able to balance the added costs associated with low-emissions investments and operation, against the economic incentives on offer. Clearly, ships that are not adequately compensated financially will have little *economic* incentive to reduce emissions.

Various factors will contribute to the choices made including (A7:2.4): the degree of differentiation; the absolute level of the fees being differentiated; the basis on which the fee is set (e.g. grt, emissions, voyage distance); the frequency with which a ship is expected to confront differentiated fees; the geographic area of application; and the ship's specific characteristics. From the ship owner's stand point the characteristics of his operation combined with the characteristics of the differentiated incentive schemes that his ship will encounter, will determine whether any particular arrangement is economically attractive.

From the standpoint of the environmentally motivated policy maker, the shipowner's decision process, integrated across all relevant shipping, will also determine the effectiveness and cost (see options EI and FII) of the scheme. Effectiveness has many measures, but, ultimately, minimisation of adverse environmental impact is paramount. Two options suggest themselves as means of offering the incentive for this policy (DI); one applied through port or shipping dues and the other applied to the bunker price at point of sale.

The former is an indirect method of tackling ship-source pollution. It would involve economic incentives being accorded to ships, notionally according to their purchases of bunkers (and so, upon their consumption of these, their emissions of SO_2), but in practice on the basis of some criteria unrelated to their pollution potential, such as gross registered tonnage, and without regard to where the bunkers in question are consumed (and so give rise to pollution). Attempts, on the other hand, to more closely relate the incentives to the purchase of bunkers consumed in European waters (and so to ship-source emissions affecting Europe) would involve attaching additional conditions to the incentive which would effectively render the instrument one concerning consumption rather than purchase, and so remove it to category EI, discussed below.

By contrast a taxation instrument applied to environmentally-differentiated fuel at point of sale, would resemble the situation at many fuel pumps in Europe. However, such an instrument could only be part of a further-reaching policy. Clearly, reducing the price differential between low and high sulphur bunkers would improve the economics of either complying with a regulatory regime (such as BI above) or taking advantage of an environmentally-differentiated shipping dues scheme (such as EI below), but would not in itself significantly reduce emissions unless the differential were eradicated. Eradication of the price difference would tend to eliminate the demand for high S products and so the effect would resemble the regulatory option of banning high S bunker sales.

Thus, as a complete policy, this option has little to commend it, though some of the above points will be returned to in the discussion of EI below.

5.7 Economic Incentive based on fuel consumed (EI)

A system of environmentally-differentiated shipping dues based on consuming bunkers with sulphur content within set limits is already operating in Sweden (Appendix 3). This study calls for an assessment of an EU-wide scheme based on three possible S levels. Appendix 7 presents a quantitative assessment of different possible systems of differentiated fees that could be implemented by EU Member States. These systems would reward ships, based on grt, for the 'continuous consumption' of low-S fuels within defined marine areas. The assessment quantifies potential uptake from such a system under three alternative maximum S levels (1.5%, 1.0% and 0.5%) as well as at three alternative 'degrees of differentiation' (low, moderate and high), for a total of nine possible combinations. A simple model is presented, through which the potential emission reductions associated with each combination are estimated.

The Swedish system requires operation on low S fuel for the complete voyage and limits the number of port visits (per year) for which the charging differential applies. These are both significant factors in the predicted effectiveness of such schemes, as is shown below.

As indicated in Chapter 4 and detailed in Appendix 7, there are many characteristics of the shipping fleet that operates in European waters that have a bearing on the voluntary take-up of incentive schemes. This is true in relation to both the consumption of low S fuels and the investment in low NO_x production (option FII below). Appendix 7 describes how the model is constructed in this regard.

Given appropriate market assumptions on fuel price differentials, the model generates average annual incremental fuel costs. These increased fuel costs depend upon the prescribed level of sulphur and the area within which the vessels are deemed to consume low S bunkers.

Table 5.7 Incremental fuel consumption costs

Ship type	Average annual incremental fuel costs per vessel @ … per tonne (all voyages) ($'000)			Average annual incremental fuel costs per vessel @ … per tonne (Euro. waters) ($'000)			Average annual incremental fuel costs per vessel @ … per tonne (territorial waters, incl. ports) ($'000)		
	…$30 (1.5% S)	…$40 (1.0%S)	…$70 (0.5%S)	…$30 (1.5% S)	…$40 (1.0%S)	…$70 (0.5%S)	…$30 (1.5% S)	…$40 (1.0%S)	…$70 (0.5%S)
Tankers	156	208	363	43	57	100	28	37	65
Dry bulk	160	213	373	44	59	103	29	38	67
Container	387	516	904	106	142	248	69	92	162
Ro-Ro	405	540	944	364	486	850	237	316	552
Cruise/Passenger	524	699	1,223	210	279	489	136	182	318
Other Cargo	137	183	320	34	46	80	22	30	52
All ships b/w 250-1,000 grt	8	10	18	7	9	15	4	6	10

From Table 5.7, the trend in increasing cost with expanding geographical area is noted. For different ship types and, of course for individual vessels, the sharpness of the increase is dependent upon the time spent in European, and, particularly, territorial waters.

Clearly any incentive scheme must, from the economic standpoint, at least cover the additional costs (or be equivalent to extra charges that would otherwise be levied). The model has been used to calculate the number of visits that an average ship in its class must make to break-even (Table 5.8).

Table 5.8 Estimated number of visits to break even under territorial waters – continuous low-S operation

	LOW DIFFERENTIATION			MODERATE DIFFERENTIATION			HIGH DIFFERENTIATION		
SHIP TYPE	1.5%S @ $30	1.0%S @ $40	0.5%S @ $70	1.5%S @ $30	1.0%S @ $40	0.5%S @ $70	1.5%S @ $30	1.0%S @ $40	0.5%S @ $70
Tankers (>1000 grt)	7	9	16	5	6	11	3	5	8
Dry bulk (>1,000 grt)	7	9	16	5	6	11	3	5	8
Container (>1,000 grt)	21	27	48	14	19	33	10	14	24
Ro-Ro (>1,000 grt)	88	117	205	60	80	140	44	58	102

The table above relates to an incentive scheme requiring low S consumption in territorial waters only. The differentiation levels applied are $0.15, $0.22 and $0.30 per grt for low, medium and high, respectively (A7:2.4.1.4). It should be borne in mind that the results quoted are the average of a distribution. This is not a table for a ship-owner to examine and expect to see numbers that relate to his particular ship.

Following from the above and the distribution of ship port visits (Appendix 7) estimates have been made of the ships that should take advantage of the scheme, on the basis of this economic argument. In this assessment it is assumed that, unlike the Swedish system, the differentiated fee would be available at each port visit. The resulting reduction in SO_2, for a territorial waters scheme, is shown in Table 5.9.

Table 5.9 Estimated SO_x Reduction from a Differentiated fees system based on Consumption in Territorial Waters ('000 tonnes)

LEVEL OF DIFFERENTIATION	1.5% S	1.0% S	0.5% S
Low	580	655	518
Moderate	643	787	702
High	669	848	879

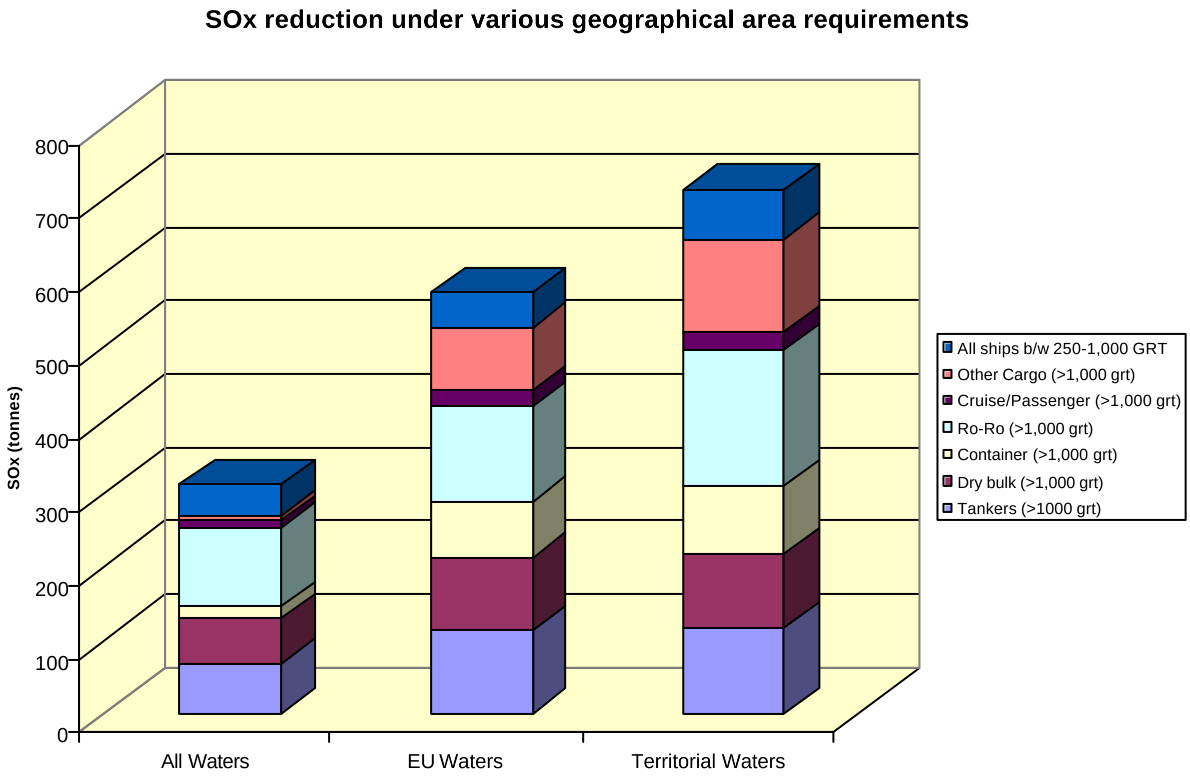
SO_2 % REDUCTIONS (KT)	REDUCTION AS % OF EXISTING PORT & TERRITORIAL	REDUCTION AS % OF EXISTING PORT & TERRITORIAL	REDUCTION AS % OF EXISTING PORT & TERRITORIAL	REDUCTION AS A % OF ALL EUROPEAN WATERS	REDUCTION AS A % OF ALL EUROPEAN WATERS	REDUCTION AS A % OF ALL EUROPEAN WATERS
Level of differentiation	1.5%S	1.0%S	0.5%S	1.5%S	1.0%S	0.5%S
Low	47%	53%	42%	30%	34%	27%
Moderate	52%	64%	57%	33%	41%	36%
High	54%	69%	71%	35%	44%	45%
Rebate costs ($m)				$/tonne reduced		
Level of differentiation	1.5%S	1.0%S	0.5%S	1.5%S	1.0%S	0.5%S
Low	1,102	1,006	777	1,899	1,536	1,498
Moderate	1,726	1,649	1,358	2,684	2,096	1,934
High	2,419	2,361	2,112	3,616	2,784	2,403

The table shows an abatement range from around 500,000 tonnes to 900,000 tonnes, which spans the estimated 600,000 to 800,000 range of the regulatory option BI. Thus based on a 1% sulphur-in-fuel limit around 40% of reduction appears feasible (similar to AI and BI) but at a cost per tonne abated of $2,000 compared with half the cost for BI.

The cost for option EI is the aggregate cost of the rebate / incentive. Those that adopt because of the incentive do so to gain an advantage. The cost will be borne either by non-adopting ships and / or in reduced shipping dues. To place these numbers in context, the aggregate "cost" of $1.5bn is of the order of eight times the annual revenue from shipping dues earned by the Port of Rotterdam[7].

As discussed in A7:2.4.1 and shown in Table 5.7 above, if the incentive scheme requires low S use over a wider geographical area then naturally the average cost of adopting the scheme will increase. The model described in Appendix 7 has been used to explore the sensitivity to the area definition. The result for 1% S content and the moderate differentiation level ($0.22 per grt) is shown in Figure 5.1. The additional costs of fuel cause a reduction in estimated up-take of the scheme and as a result the environmental benefit is projected to reduce. Not only will the emissions in aggregate be reduced, but also the consumption of low S fuel will move further off-shore.

Figure 5.1



The foregoing refers to a system of differentiated fees in which fees are based on grt. Gross registered tonnes were indeed defined to provide a means of allocating commercial charges. However, the analysis has pointed to a number of constraints under which this type of system is forced to operate. These include the following:

[7] Rotterdam Port web site – key statistics for 1997. Dues 405 million guilder ($176m)

- A grt-based fees system is not linked either to fuel consumption or emissions. Not only does grt not necessarily correspond to fuel consumption rates, more importantly it bears scant correlation to voyage length.
- When looked at as a rebate, grt-based differentiation may tend to 'over-reward' short-sea ships while 'under-rewarding' long voyage ships which may incur significant expenses on low-S fuels, depending on the geographic area covered.

In environmental economic terms, a system that were related to fuel consumption (or better still pollutants emitted) rather than grt would be the most efficient solution, with the potential to require ship operators to fully internalise the external costs of their emissions. Ships would have the choice of paying higher prices for low-S fuels or paying additional fees *in direct proportion to the foregone incremental fuel costs*. The level of the fee differentiation, in this example, would be set in relation to the normal incremental fuel cost (depending on the individual ship and distance travelled or to be travelled) within the pre-selected geographic area. This approach could require more sophisticated verification and compliance mechanisms, but is a point that is returned to in 5.10.

The selection of the regulated area, e.g., territorial seas vs. EEZs vs. all waters, poses interesting legal and economic issues. In theory, there must be an optimum regulated area within which marginal costs of low-S fuel consumption are less than the marginal benefits of reduced emissions. Beyond this hypothetical line, given the assumed reduction in damages as distance from shore increases, marginal costs would exceed marginal benefits. Thus, from an economic perspective, the regulated area should approximate the above-mentioned borderline. If this meant regulating only within the territorial sea, this could imply a differentiated fee schedule varying according to actual S-levels as well as distance travelled or to be travelled within the territorial sea. Ideally, of course, the reward scheme should relate directly to SO_2 emitted.

Thus analysis of this option suggests that a European wide scheme that took a lead from the existing Swedish system could deliver a 40% reduction in emissions (similar to the regulatory options), providing the region of application of low-S fuel consumption were restricted (probably to territorial waters) and providing a suitably high level of fee differentiation could be levied. However, although more difficult to administer, it is recommended that there is more long term benefit and logic in moving away from "grt based methods" toward differentiation directly related to emissions (see also section 5.10).

5.8 Economic Incentive based on Stack Emissions of SO_2 (FI)

As discussed in section 5.5, because of the direct relationship between sulphur content, fuel consumption and SO_2 emissions, it is possible to frame a fuel requirement in terms of an emission rate. Further the desirability (section 5.7) to move more toward fuel consumed / SO_2 emitted argues in favour of always permitting the alternative of a technical exhaust gas treatment method of achieving the target levels.

The issues of ensuring a particular level of emission and adequately dealing with waste products, suggests that in practice 'fuel content' solutions will most commonly be adopted. Thus option EI can be thought of as a specific sub-set of FI. Adoption of the FI incentive scheme should lead to similar emission reductions to EI. Greater reductions will occur only to the extent that more economical exhaust treatment processes become available and suited to particular ships.

5.9 Economic Incentive based on Stack Emissions of NO_x (FII)

NO_x abatement requires modification to the combustion process or treatment of the exhaust stream. The available methods based on engine timing, water injection, HAM, SCR and their variants are described in Appendix 5 and Appendix 7 (see also Kågeson 99).

A voluntary incentive-based system is a clear possibility and the existing Swedish scheme (Appendix 3) is an example. Appendix 7:3 presents a detailed analysis of a possible European scheme.

The analysis assumes that a ship once equipped with a low NO_x capability, will utilise it at all times in European waters. The main focus, as called for in the study brief, is to consider the impact of systems based on particular NO_x levels, namely 7 g/kWh and 2 g/kWh. In practice an arrangement that rewarded on a continually varying reduction basis from 12 g/kWh (as in the present Swedish system) would be preferred as discussed later.

From the available data (Appendix 7) it is deduced that the 30,000 vessels active in European waters have an average power of 6.1 MW, an aggregate installed power of in excess of 180,000 MW and an overall annual power consumption of 170 million megawatts. This activity is estimated to generate 2.3 million tonnes of NO_x from ships from the defined European waters (see Table 5.1). These statistics lead to an average generation rate of 13.5 g/kWh and demonstrate the small environmental impact that the implementation of MARPOL's Annex VI NO_x regulations could have. Not only are the IMO limit curve levels (16 g/kWh (slow speed) to 12 g/kWh (medium speed) to 10 g/kWh (high speed)) modest reductions relative to the current situation, but also the application to new build and major retro-fit will ensure slow progress towards even this target.

The model (A7:3.2.3 and termed *Composite Analysis* in Table 5.10 below) works through the estimation of annual costs for the operation of SCR and Water Injection systems in order to establish the target that an incentive system has to meet before it makes economic sense for an operator to consider investing in NO_x abatement equipment. For a system relying on shipping dues rebates or benefits based upon grt, the operator's decision then critically revolves around the number of port visits expected to be made and the level of the differentiated fee.

These are complex considerations for an operator, especially if the activity of its ships in European waters is unpredictable. The operator will need to include in his consideration the degree to which it makes economic sense to abate. This will depend upon the relative cost of the abatement technologies and the flexibility of the incentive scheme to reward progressively lower emission levels.

In our analysis we have assumed that the incentive system would be the same in all EU ports. To do otherwise would have made the modelling intractable, but this is also relevant to the owner's consideration prior to a NO_x abatement investment. If faced with different port systems such that his particular analysis were yet more complex, the likelihood would be that many would choose not to invest.

We have also assumed that the investment choice would be based on economic grounds. In fact, because of the size of the investment in capital equipment, an owner would only invest if doing so brought a return comparable with other 'business opportunities' available (A7:3.2.4). There may at times be other drivers, such as customer pressure, policy imperative or environmental concern. Indeed this must be the case in the Swedish system as Kågeson 99 indicates that *the fairway rebate enjoyed by a frequent visitor usually covers only one quarter to one third of the additional cost*.

Generally, however, this is unlikely to be the case and we assume that the incentive scheme will need to be economically attractive. As a result incentive schemes are likely to be expensive. For example, for a particular ship type and NO_x system an appropriate investment return would correlate with a certain fee rebate and a certain number of port visits. In the event of more visits the ship operation would reap a further gain, presumably at the expense of other users. While it may be possible to limit the number of visits (as in the Swedish system) on which the incentive is applied, Appendix 7 shows this also to be complex. For example, Figure 5.2 shows for average ships in certain class types, the number of visits required to trigger investment. In these examples, the triggers are for investment in: water injection to achieve around 7 g/kWh; in SCR to achieve around 2 g/kWh; and to choose SCR over water injection (switch point) providing the incentive scheme allowed for a varying reward. Appendix 7:3.2.4 describes the assumed incentive cost levels to arrive at these estimates.

Figure 5.2 Number of annual visits needed to induce adoption of SCR and WI, by ship type, moderate differentiation scenario

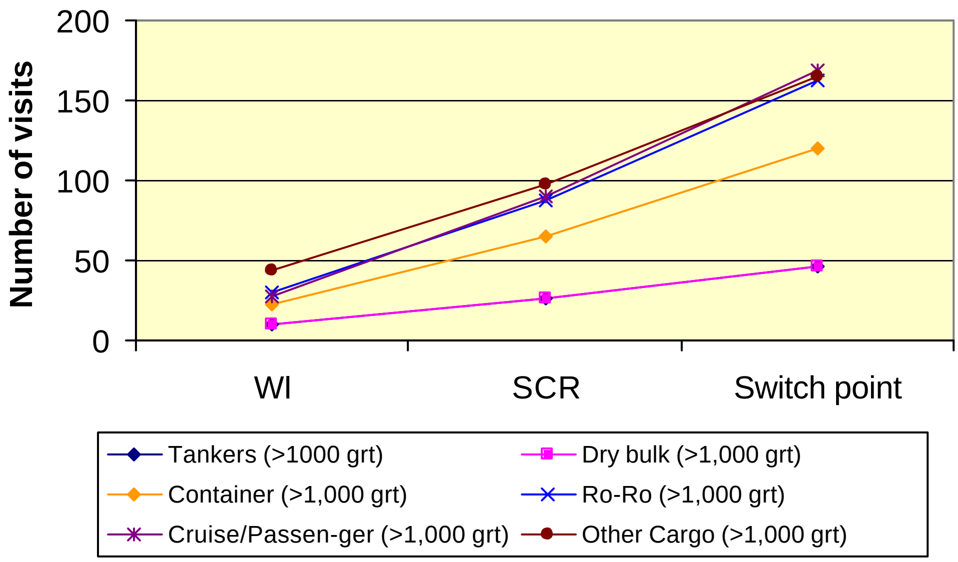


Table 5.10 Estimated NO_x Reduction from a Differentiated Fees System based on Stack Emission Limits ('000 Tonnes)

NO_x REDUCTION IN EU WATERS	MILD INCENTIVE	MODERATE INCENTIVE	STRONG INCENTIVE	100% COMPLIANCE
Limit 12 g/kWh	4.8%	9.8%	11.2%	11.8%
Limit 7g/kWh	8.9%	34.5%	46.2%	49.3%
Limit 2 g/kWh	0.0%	49.9%	57.4%	86.9%
Composite Analysis	20.4%	47.1%	64.7%	
COST PER ANNUM ($M)				
Limit 12 g/kWh	41	83	101	109
Limit 7g/kWh	156	457	706	771
Limit 2 g/kWh	0	1,398	1,538	2,858
Composite Analysis	291	1,484	3,215	
COST PER ANNUM PER % OF REDUCTION ($M)				
Limit 12 g/kWh	8	9	9	9
Limit 7g/kWh	17	13	15	16
Limit 2 g/kWh		28	27	33
Composite Analysis	14	32	50	

The figures in Table 5.10 above seek to summarise a number of results from the analysis of this economic incentive option.

Firstly, and for reference, the column "100% compliance" represents our estimate of the position that would exist if all ships operating in European waters achieved, respectively, the limits of 12, 7 or 2 g/kWh. This column presents therefore limiting values against which an incentive scheme can be assessed for effectiveness.

The first section of the table shows the resulting NO_x reduction in the defined European waters. The span is 12% to 87%.

The second section for this column predicts the cost to the ships in question, on the basis of the available technologies and prevailing cost estimates (Appendices 5 and 7). The third section converts these costs to the common base of cost per percentage of NO_x emission reduced.

The three columns, in Table 5.10, headed *mild, moderate* and *strong* refer to the fee differential per grt set out in A7:3. The incentive varies with degree of NO_x *reduction*. The upper limits of rebate are *mild* to \$0.1; *moderate* to \$0.3; and *strong* to \$0.5. Generally the differentiated fee level has been set at a higher level for NO_x than SO_2, because of the capital investment required in the former.

For the fixed limits (12, 7, 2 g/kWh) take-up of the scheme has been computed as follows. A ship is deemed to accept the incentive, if the incentive per grt earned over the average number of port visits for its vessel type, is sufficient to cover the annual operating costs of the NO_x abatement system. The average number of port visits is taken from the "Total Visits" column of Table A7:7.12.

Thus, for example, for all tankers it is assumed that they will look to cover the total annual investment and operating costs for NO_x abatement over 27 port visits.

So (Table 5.10) it is predicted, for example, that if a fixed limit of 7 g/kWh were set and a moderate economic incentive were available, then sufficient ships would adopt to produce a 35% reduction in NO_x emissions. If the incentive were mild then the effect might be as small as 9%, or strong as high as 46%, which begins to approach the theoretical maximum that could be achieved of 49%.

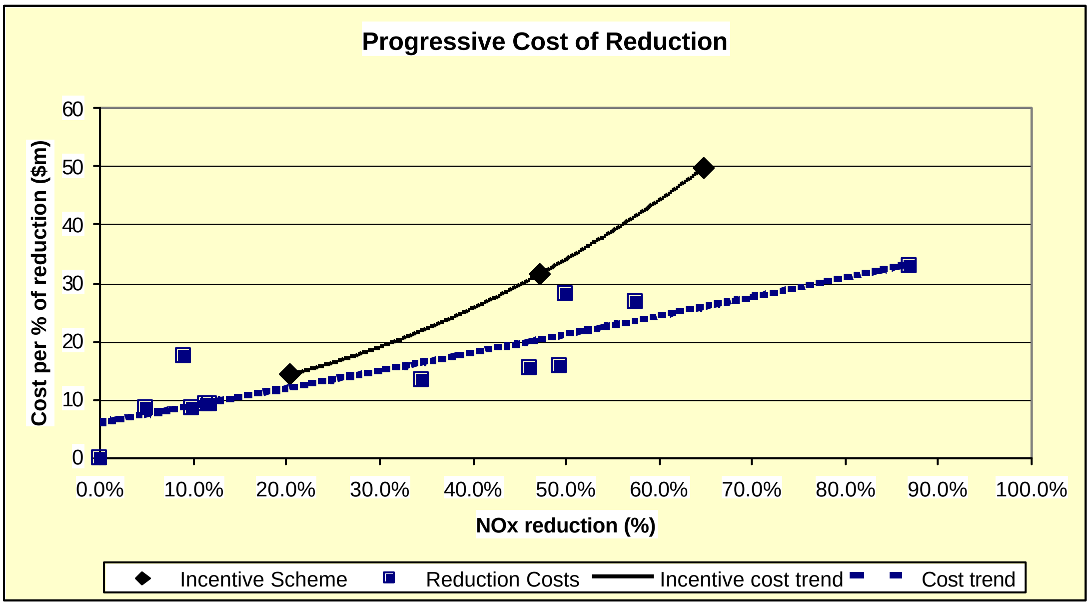
For these "fixed limit" emission criteria the costs quoted in Table 5.10 are the actual costs of NO_x abatement, **not** the cost of the incentive scheme. This helps draw out (below) the cost of incentive schemes. Clearly an owner that bases his investment decision on an assumed number of visits (over the full write-off period of his capital investment – say 8 years), will recover more than his costs if the ship continues to receive the differentiated fee benefit when the number of visits exceeds his initial criterion.

So far the discussion of Table 5.10 relates to estimates for fixed emission levels (unlikely to be the preferred system) and these act as comparisons for the more sophisticated scheme (*Composite Analysis*) described at the beginning of the section that seeks to reward on degree of abatement achieved (even this model uses a stepped approach rather than a continuously varying rebate vs. abatement curve).

The predictions in Table 5.10 show that the flexibility of a variable scheme (*Composite Analysis*) can, at times, lead to more effective reductions than a fixed emission-level incentive scheme. For maximum effect, for example, the strong incentive shows greater reductions for the *composite analysis* over the fixed limit of 2 g/kWh (65% vs. 57%). This is because for those ships (factors are number of visits, size, present emission level) for whom the incentive is not great enough to go to 2 g/kWh, there may well nonetheless, be a reduced level that can be achieved using a lower unit cost technology (e.g. preferring water injection over SCR).

The modelling suggests that incentive schemes could be devised to produce emission reductions of as much as 50% at a cost in the region of $1.5bn or $1,400 per tonne of NO_x abated (for a similar overall cost, section 5.7 predicted a 40% reduction in SO_2). Attempts to induce much greater take-up of incentive schemes are likely to face sharply rising costs of the scheme, as shown in Figure 5.3 below and Table 5.10 above. The figure shows the likely widening gap between the reduction cost curve and the trend for the cost of the incentive scheme.

Figure 5.3



An overall summary of the composite analysis in terms of European waters is given in Appendix 7 and repeated in Table 5.11 below.

Table 5.11 Estimated NO_x emissions by marine area under various scenarios ('000 t)

MARINE AREA	BASELINE	LOW DIFFERENTIATION	MODERATE DIFFERENTIATION	HIGH DIFFERENTIATION
Baltic Sea	365	291	193	129
North West European	990	788	524	350
Mediterranean Sea	520	414	275	184
NE Atlantic	433	345	229	153
Total European waters	2,308	1,837	1,221	815
% reduction		20.1%	46.3%	63.7%

For the Mediterranean a 50% NO_x reduction is indicated (Table 5.11) to amount to 260,000 tonnes per annum. If the Lloyds Register (2000) estimates are used instead, the potential for reduction is increased threefold. A policy that removed between 300,000 and 800,000 tonnes per annum would clearly be of considerable value in alleviating the ground level ozone problem that this region suffers from.

At a level of 50% NO_x reduction the model predicts that 36% of ships active in EU waters would need to invest in abatement measures, but that 64% of port visits would receive the differentiated fee benefit. This illustrates the difficulty of considering a cost-neutral policy – the burden of a significant incentive for 2/3 of the port visits falling on the remaining 1/3, albeit on a larger number of ships than receive the incentive. In other words the cost neutral balance would be achieved by the less frequent ocean-going transcontinental ships funding the rebate provided to the more local frequent visitors. The former category of ships would have no economic alternative other than to pay the higher dues, because their visit pattern would be insufficient to warrant the NO_x investment. Alternative methods could be preferable (see 5.10 below).

In our analysis we have used models to explore the issues and provide indicators of the likely outcome. All schemes, however, can be "tuned" to be more or less effective in particular matters. Completely reliable analysis results are, of course, frustrated in part by the lack of complete statistical data for European shipping (see section 4.2), but, more importantly, are elusive due to the influence that government and EC policies may exert on shipping activity and the likelihood that some shipowners will not make rational choices with respect to NO_x abatement measures.

5.10 Issues and Findings

The quantitative analysis discussed in this chapter above (and in Appendix 7) are summarised graphically below in Figures 5.4 to 5.7. The figures indicate the main results and raise a number of issues.

Figure 5.4 Options for SO_2 Reduction

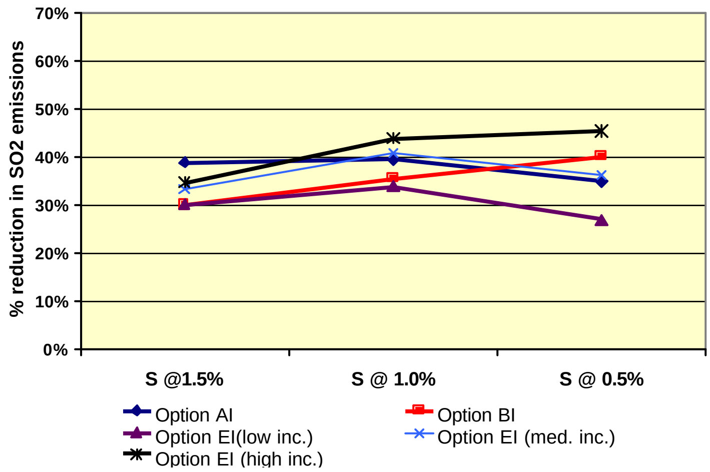
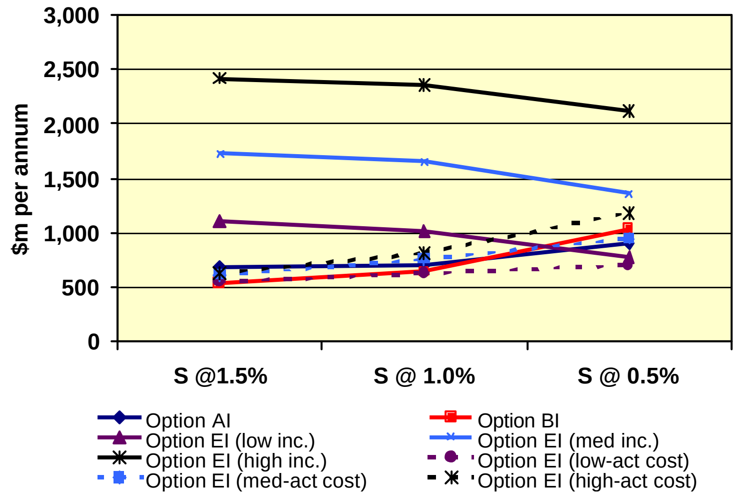


Figure 5.5 Cost of SO_2 Reduction Options



Broadly speaking, the regulatory and economic incentive options may be expected to produce reductions in SO_2 emissions of 30% to 40% (Figure 5.4) and for NO_x an incentive scheme to produce similar results (but over a longer period of time) can be devised. However, the cost can vary considerably depending upon the policy method. In Figure 5.5, the regulatory options are stated as the cost to shipping of complying. The economic incentive options are shown in terms of the incentive rebates and additionally (broken lines) as the cost incurred by the ships that adopt the environmentally-differentiated fees scheme. In providing a true economic incentive the returns for adopting must exceed the costs of adopting. However, the gap can be large, perhaps sometimes unacceptably so. The same is true for the NO_x incentive scheme that has been discussed. The gap widens increasingly with efforts to achieve reductions greater than 40% or so (see Figures 5.7 and 5.8).

Figure 5.6 NO_x Reduction Options

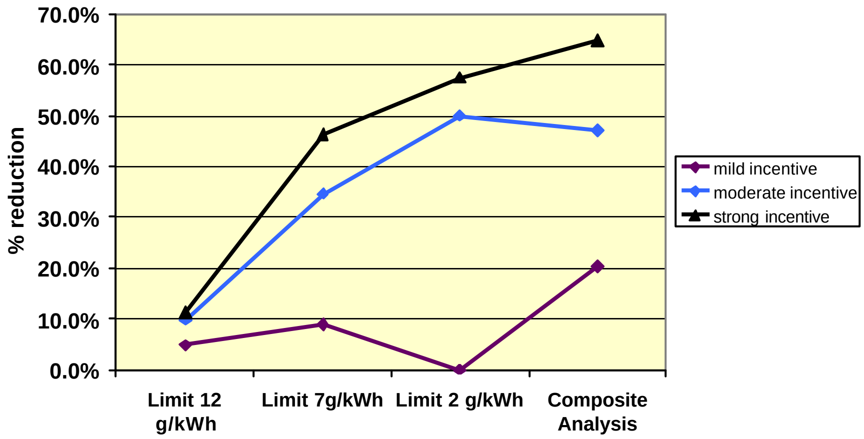
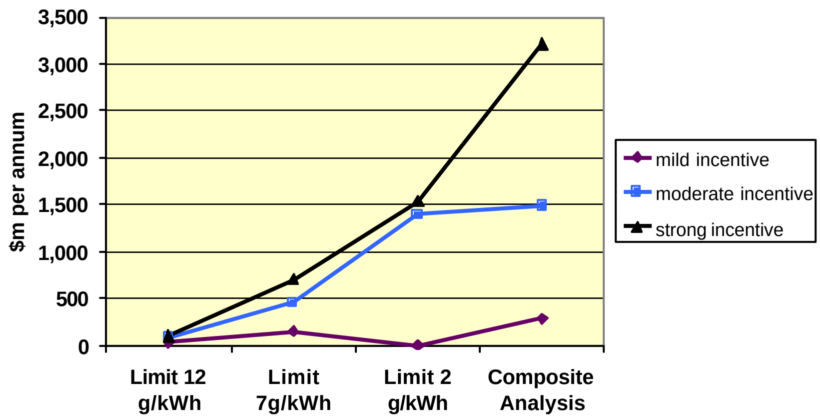


Figure 5.7 NOx Reduction Costs

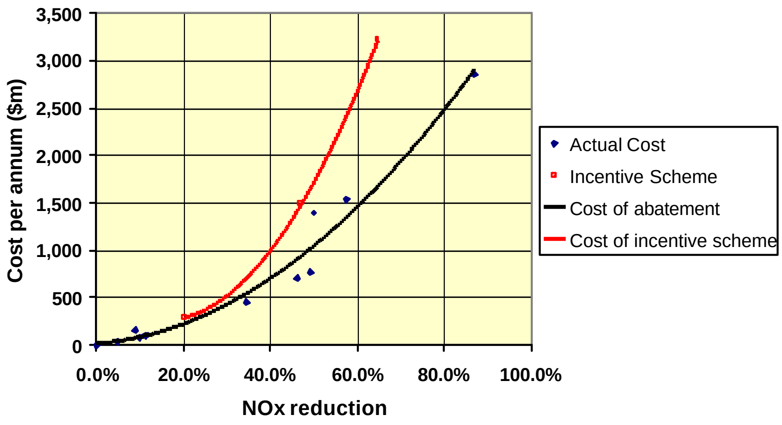


Thus an effective incentive scheme must be very carefully constructed and, if it is to be cost efficient, as directly related as possible to emissions and emission abatement costs. Measures based on grt and linked to shipping dues are far from ideal.

The concept of using adjustments to port dues is also far from ideal from the point of view of port operations. Whilst many European ports remain in public ownership, nonetheless there is a general move toward commercialisation and privatisation. Already in many ports, port fees are negotiated and not necessarily related to published tariffs. For example, a port and a container shipping line with a commercial contract based on number of containers handled may have no charges related to the ship's grt at all.

It is evident from the foregoing that an environmentally-differentiated incentive scheme can involve considerable financial exposure, given the uncertainty of up-take. This will be further increased if the scheme offers financial assistance towards investment in NO_x abatement. Realistically the responsibility for an incentive scheme is a matter for the state rather than the (commercial) ports and this offers the opportunity to move charging away from the port dues concept to an emissions measure.

Figure 5.8 NOx Abatement Costs



A relatively simple method is shown below:

For SO_2

Assumed fuel consumption, F (tonnes):

F = [80% of installed power (MW)] x **[hours sailing in designated waters]** x **[0.2 tonnes of fuel/MWh]**

Assumed SO_2 emission (based on 3% S in fuel), S (tonnes):

S = F x **0.06**

Assumed cost of reducing to 1% S in fuel, C($):

C = F x **40**

Suggested levy for not abating SO_2 emissions, L($):

L = C x **1.1**
[levy per emitted tonne of SO_2, between 1%S to 3%S, **r**($)=L/(0.667S) = **$1,100**]

Relief from levy / rebate, R($):

R = [S – actual fuel consumed x **actual S content** x **2]** x **1,100**

The above is an example and clearly the parameters can be adjusted. The principle is a "standard" charge that is readily calculated. The charge is paid unless the ship provides evidence of lower emissions. The evidence required is relatively straightforward; namely, the actual fuel consumed in the designated area and the sulphur content of the fuel burned. The "designated area" is a matter of policy. It could be all European waters, as the method recognises distance sailed and is less constrained in this respect than the policy EI, where we recommend the designation to be territorial waters.

The charge is set 10% higher than the expected cost of achieving a low sulphur fuel content of 1%, so as to provide an incentive if the charge is rebated.

As an example, consider a vessel with installed power of 10MW and a 24 hour voyage to the port in question. The standard levy would be calculated as:

F = 38.4 tonnes; S = 2.3 tonnes; C = $1,536; L = $1,690

Consider an actual performance of only 30 tonnes of fuel used with an S content of 1.5%, then the rebate would be:

R = [2.3 – 30 x 0.015 x 2] x 1100 = $1,540

Or a net charge of: $1690 - $1540 = $150

If the ship used 1% fuel then the rebate would exceed the charge and give a credit of $180. In this case, the fuel premium is assumed to be $1200 (30 tonnes x $40), so the net cost to the ship, with the credit, would be $1,020 (and 1.2 tonnes of SO_2 emissions would be saved). This compares with a charge of $1,690 if the ship had not taken abatement measures.

Economically this scheme shows an incentive to reduce emissions; whether the incentive is sufficient is difficult to estimate. A possible combination of measures would be to require by regulation that fuel burned in port[8] (and/or territorial waters) should have a sulphur content not in excess of 1%, together with the above levy and rebate system.

Clearly the above system differentiates in terms of charges in favour of the lower polluter, but the net result does remain an increased cost to shipping. The advantage of the above is to tie the incentive scheme cost more closely to abatement costs. This scheme charges at around $1,100 per tonne reduced, whereas option EI (based on grt) leads to $1,500 to $2,000 per tonne (Table 5.9).

The subject of providing information for charging and rebate purposes is returned to after discussing NO_x below.

For NO_x

Assumed NO_x production N (tonnes):

N = [80% of installed power (MW)] x **[hours sailing in designated waters]** x **[0.014 tonnes /MWh]**

Assumed cost to abate to, say, 2 g/kWh (A5 & A7): $535 per tonne, therefore cost C($):

C = 460 x **N**

Levy, L($), with 40% margin (a higher margin than for sulphur because more significant investment is required):

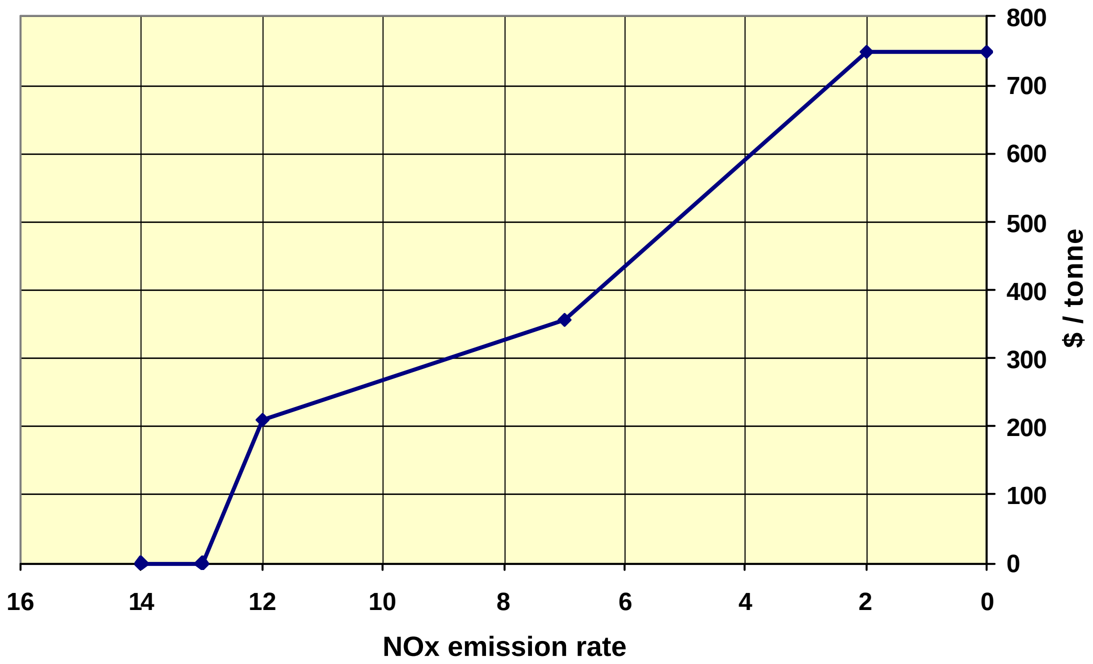
[8] Say defined in relation to the pilot boarding station – irrespective of whether the ship has a pilot exemption certificate or not. This would be similar to the historic practice of ships using diesel for manoeuvring in port (Appendix 5)

L = C x **1.4**

Relief from levy / rebate, R($):

R = [N – actual MWh x **actual emission rate]** x **r**
where **r** ($/tonne) is taken from the graph below.

Figure 5.9 NOx Rebate / tonne



Thus following the SO_2 example above:

Table 5.11 Example application of NO_x levy (based on 192 MWh)

	NO_x PRODUCED (TONNES)	NO_x REDUCED (TONNES)	REBATE ($)	NET LEVY ($)	COST TO SHIP ($)
No abatement	2.7			1725	1725
Abatement to 12 g/kWh	2.3	0.4	81	1644	1702
Abatement to 7 g/kWh	1.3	1.3	479	1246	1588
Abatement to 4 g/kWh	0.8	1.9	1152	573	1494
Abatement to 2 g/kWh	0.4	2.3	1725	0	1232

The method of charging and rebating illustrated above for SO_2 and NO_x, involves the imposition of an emissions charge and relief from it according to the rebate method described. More or less encouragement and assistance in meeting the cost can be achieved by adjusting the mark-up margins for the levy (10% and 40% in the above examples). If such a method were employed then the charges would need to be kept under review in light of market price trends for SO_2 and NO_x abatement methods. Revenues raised by these charges could be used to aid investors in emission reduction equipment.

The practical operation of such a system should be relatively straightforward, though it certainly does not mean no new paper work (see Hader et al, 2000). In the absence of a statement from a ship on emission reduction the standard charge would apply. The only information required and needing verification is ship's power and voyage duration in European waters.

To claim a rebate, we suggest that the ship provides a statement of fuel consumed in European waters, fuel sulphur content (or FGD emission if installed as an alternative), power consumed (MWh) and NO_x emission rate. Support to the claim should include bunker receipts and manufacturer's certification of NO_x equipment (following IMO NO_x Code). The ship's statement should in general be accepted at face value, albeit subject to Port State Control investigation at any time. However, ship's records and information are not always reliable. A solution to this unreliability is suggested in Chapter 3 and Appendix 4 and relies on the submission of unreliable information being treated as a continuing offence. We suggest that this should be applied to declarations of emissions as required above.

Beyond Port State Control, the involvement of national Environmental Agencies to review the consistency of emissions claims might be worthy of consideration.

Finally in the broader picture of transport and sustainability in Europe, there is much encouragement for shipping to play a greater role in the inter-modal transport chain, thereby relieving land (particularly road) transport requirements and impact. The environmental benefits claimed for more short sea shipping, would clearly be enhanced by further reductions in ship emissions. On the other hand it is a matter for careful policy management as the initial effect will be to increase shipping costs.

6. CONCLUSIONS AND RECOMMENDATIONS

1. Emissions of SO_2 and NO_x from ships in European waters, as defined in this Study, represent some 30% - 40% of the planned total of 'EU' emissions in 2010.

2. On the basis of the planned reductions, emissions in 2010 are still projected to cause exceedence of critical loads for ecosystems. Across Europe as a whole exceedence by 4% is estimated, but much higher exceedences are projected for the Netherlands (60%), Belgium (22%), Germany (16%) and the UK (12%). Also in some regions (notably the Mediterranean) ground level ozone is a problem of concern and NO_x emissions contribute to its formation.

3. Clearly, there is scope for shipping to make a contribution to emissions reduction and help to close the gap between the expected results of currently planned actions and the desired position of eliminated exceedences of critical loads and improving air quality.

4. MARPOL's Annex VI is not yet in force, but even when it comes into effect the very modest requirements for both SO_2 and NO_x, will make very little contribution to emissions reduction in European waters, in general. For SO_2 the recent adoption of the North Sea as a SO_x Emission Control Area will have a positive effect, reducing the base level emission against which this study has made its assessments by 5% to 7%.

5. This study has produced a new quantification of emissions in all European waters, giving rise to integrated totals for the defined waters of the Baltic, N W European waters, the Mediterranean and the N E Atlantic.

6. Shipping in European waters is the equivalent of 390 power plants of 50MW running continuously. The net effect is the generation of 1.9 million tonnes of SO_2 and 2.3 million tonnes of NO_x per annum. The most pronounced areas of emission are the main shipping lanes from Suez to Gibraltar, along the west coast of Europe, including the Western Approaches to the English Channel, through the Channel and along the northern European coast towards the Kiel Canal and the Baltic Sea. Other more localised areas are in the northern North Sea, in the Adriatic Sea and off the French Mediterranean coast.

7. EU regional action to tackle ship emissions is legally possible by means of environmentally differentiated incentive schemes and, in some cases, by regulatory instruments, even where these go beyond global international standards, such as those in MARPOL Annex VI.

8. Regional regulation of foreign transiting vessels in European territorial seas and beyond is not feasible for NO_x, as it would require the imposition of CDEM ('construction, design, equipment and manning') rules and standards higher than generally accepted international CDEM rules or standards. In-port NO_x regulations having the practical effect of imposing permanent requirements at higher-than-international levels on foreign ships are also likely to be met with strong protests.

9. Regional regulation of foreign transiting vessels in European territorial seas is feasible for SO_2, providing it can be regarded as imposing emission, rather than CDEM, rules and standards. That it can be so regarded can be persuasively argued on the ground that there is a direct correlation between fuel sulphur-content and emissions and that the emission standard can be met simply by burning low S fuel. In-port SO_2 emission regulations will not have the practical effect of imposing permanent requirements on foreign ships.

10. The off-shore "reach" of any regulation of SO_2 emissions is, however, limited. Prescription of rules and regulations should be restricted to territorial waters, and enforcement should generally take place in port.

11. The estimated effect of EC legislation regulating SO_2 emissions by setting limits on the sulphur content of fuel consumed by ships in territorial waters, is likely to be a reduction of 30% - 40% of total present emissions. However, port areas and territorial waters should receive greater proportional benefits. Reductions of 60% and 45%, respectively, have been estimated. This is an important difference, as the environmental impact analysis confirms the greater importance of emissions close to shore.

12. It is possible, and perhaps desirable, to consider a combination of regulatory and incentive-based instruments to reduce SO_2 emissions. The most likely regulatory component of such a combination would be a limit on the sulphur content of fuel consumed in port (between, let us say, the pilot boarding station and the wharf or terminal). This would be technically feasible and would restore the historic practice of using diesel, rather than heavy fuel oil, for in-port manoeuvring. The modelling carried out in this study suggests that a sulphur limit of 1%, would be most cost-effective.

13. A 1% S limit would also tie in with the EC Liquid Fuels Directive, which is primarily aimed at non-marine emitters. A rough analogy between ports and Large Combustion Plants (LCP) points to considering Europe's top twelve ports as having sufficient installed ship power in port to be considered as LCPs. Thus, from the environmental perspective, any policy aimed at tackling ships through their presence in port must ensure that the policy can work in the context of the major port complexes of: Rotterdam; Antwerp, Marseilles; Hamburg; Le Havre; London; Amsterdam; Genoa; Wilhelmshaven; Dunkirk; Bremen and Zeebrugge.

14. The study predicts that a regulation limiting sulphur content at point of sale in Europe (irrespective of use) could also reduce emissions by up to 40%. In contrast to a consumption regulation, there are no significant legal difficulties in doing so, but the distortion to the present bunker market would be significant. Present bunker exports would be curtailed, the resulting consumption pattern would not be optimised for reduced environmental impact and an incentive for ingenious avoidance of European bunker purchases would be created.

15. This study concludes that of the regulatory options for SO_2, a consumption regulation with limited geographical extent is to be preferred. A regulation on consumption, with a limit of 1%, is likely to reduce emissions at a cost of $1,000 per tonne of SO_2 emission abated. A 35% emission reduction achieved this way would cost shipping an estimated $700 million *per annum*. [Note: the cost cited depends on the assumptions made for future fuel prices. IIASA for example have assumed differential prices of approximately half those used in this study – see

Appendix 5].

16. The marginal cost of limiting S content to 0.5% is high and the return predicted is modest.

17. Whether tackling SO_2 emission reduction by regulation or economic incentive, it is recommended that the requirements are phrased such as to allow low S fuel consumption or an equivalent stack emission treatment. Additional demonstrations of environmentally acceptable operation should be required for the use of flue gas de-sulphurisation.

18. Existing economic incentive schemes basing environmental differentiation on the S content of fuel or the level of SO_2 emission have been studied, and possible EC-mandated schemes modelled. A scheme based on rebates of port / shipping dues can be made practically effective, although, it appears most environmentally effective to relate the use of low S fuel in the scheme requirements to territorial waters only and to apply the rebate / charge to all visits to a given port. These features stand in contrast to those of the foremost existing model, operating in Sweden.

19. Constructing schemes that have a neutral effect on port revenues is extremely difficult, and becomes more so the greater the level of adoption of the scheme. In addition, methods, like Sweden's, employing calculations based on vessels' gross registered tonnage ('grt') are a clumsy way of tackling emission reduction and would seem to run against the spirit of flexibility of charging systems tied up with the trend towards port commercialisation and privatisation. A system of levies and rebates operated at the national level is suggested as an alternative to a port - based system. The latter can more easily be related to pollution caused and abated, and can more easily be configured to accommodate any level of reduction that a ship achieves, rather than a set level. The costs can more readily be controlled and there is no longer the same requirement to restrict its application to territorial waters.

20. It is estimated that the SO_2 incentive schemes may lead to emission reductions of between 30% and 40%. A 'grt'-based incentive scheme may, however, require a rebate level that equates to $2,000 per tonne of SO_2 abated, approximately double the regulatory cost. The preferred 'emissions levy' scheme can be economically worthwhile at $1,100 per tonne.

21. It is concluded, for control of both SO_2 and NO_x emissions that a nationally operated, but port-administered, levy system (based on emissions rather than grt, and not based on port-dues) is to be preferred to a port-based, port-dues-linked scheme.

22. This study has used the principle that an 'incentive' must do more than just cover costs. However, judging the level of incentive required to change behaviour is not straightforward. This is particularly true for NO_x emission reduction, where it is necessary for the shipowner to invest in capital expenditure. In this study the required return on such an investment has been set at 12.5%, to mimic a potential criterion for capital expenditure that an owner might impose. It is noted that the Swedish scheme of rebates for NO_x does not cover the costs involved. It is not expected that shipping generally in Europe will convert without a genuine incentive, albeit only a differential incentive, as overall costs will rise if emission reductions are to be achieved.

23. Ultimately, a NO_x incentive scheme may be capable of producing up to 50% emission reduction. The greatest uncertainty concerns the pace of adoption. It will undoubtedly take many years to achieve this level.

24. Achievement of NO_x reductions of this order by incentive schemes is estimated to cost between \$800 and \$1200 per tonne of NO_x abated. The lower cost applies to an emission-based levy and the higher cost to a 'grt'-based port dues scheme. The emission levy scheme offers the possibility of using income raised to encourage the investment in NO_x reduction equipment, thereby hastening the up-take. This could particularly benefit the Mediterranean, where NO_x contributes to the problem of ground level ozone formation.

25. The most environmentally effective incentive schemes for both SO_2 and NO_x are likely to be those that accommodate varying levels of reduced emissions with correspondingly varying levels of incentive. Suggested rebate variations are given in the report.

26. While administration of incentive schemes must necessarily take place in port, it is argued that the financial schemes should be separated from port dues. Minimum additional paperwork is, of course, desirable but even the simplest of schemes will require extra administration by the port and the ship.

27. It is concluded that wherever possible administration of incentive schemes should be by "self assessment" rather than by direct policing or administrative action. Simple standard charges should apply if no rebate is being claimed. Statements by a ship claiming a rebate could be accepted at face value (though subject to Port State Control inspection on occasions), but the declaration by the ships would then be part of condition that requires the correct completion of logs and record books to be a condition of port entry and to treat the provision of incorrect information as a continuing offence regardless of when and where the duty to provide it arose.

28. As an adjunct to the role of Port State Control, Member States might consider the involvement of national environmental agencies in monitoring the consistency and reliability of emission reduction claims.

29. Overall the achievement of substantial emission reductions of the order of 40% or so is feasible from a combination of measures reviewed in this study. The likely cost to shipping is estimated to be in the order of \$3 billion per annum (using the price assumptions of this study). In view of the growing desire, as part of EU's sustainable growth plans, to move the carriage of more goods from land to sea in Europe, it will be valuable to involve the relevant shipping, port and oil company stakeholders in this discussion at an early stage.

7. TECHNICAL ANNEX TO CONTRACT

Study on the economic, legal, environmental and practical implications of European Union system to reduce ship emissions of SO_2 and NO_x

1. OBJECTIVE

The objective of this study is to investigate two potential European Union instruments to reduce ship emissions of SO_s and NO_x. The instruments to be investigated are

1) environmentally differentiated shipping dues, in particular port dues;

2) regulated sulphur content in marine bunker fuel.

- The study shall analyse the economic, legal, environmental and practical aspects of introducing these instruments. It shall investigate geographic scopes of the instruments in the following sea areas (or distance from coast in these areas): the Baltic Sea, the North Sea and the Irish Sea, the Mediterranean and the north-east Atlantic.

2. BACKGROUND

The Commission and the Environment Council have decided that the community will respond actively to the outcome of the conference of the International Convention for the Prevention of Pollution from Ships (MARPOL) in September 1997 concerning the new Annex VI on air pollution from ships.

At that conference measures to reduce sulphur emissions from ships were only agreed for a very limited region (The Baltic Sea). However, analyses carried out for the Commission's communication on a community Strategy to combat Acidification (COM (97) 88 final) showed this to be a cost-effective strategy in a much wider area comprising the North Sea and parts of the north-east Atlantic.

The Environment council stated in its conclusions on a Community acidification strategy of 16 December 1997, in the paragraph on ship emissions, that:

"The Council considers it important to tackle vigorously the reduction of acidifying emissions from ships …… the Commission should, where appropriate, explore additional options for the reduction of acidifying emissions from ships".
Finally, in Article 7.3 of the common position on the proposal for a Council Directive relating to a reduction of the sulphur content of certain liquid fuels, the commission is charged with considering further measures with regard to marine fuels and, if appropriate, make a proposal by the end of 2000.

3. SCOPE AND CONTENTS

3.1 Scope of the study

Collection of information

The consultants shall describe the emissions of SO_2 and NO_x from shipping (excluding inland waterways), and their contribution to levels of SO_2, NO_x, and ozone, and deposition of sulphur and nitrogen in different areas in Europe.

The Member States' port due system and income generated from ports should be presented.

The Swedish system for environmentally differentiated port and fairway dues, the Dutch initiative on a "Green Award" scheme for environmentally friendly ships, and a Norwegian system to stimulate lower air emissions (in case it will be finalised) should be presented. The Council Regulation (EC) N0.2978/94 concerning reduced charges of oil tankers by port and harbour authorities for ships with segregated ballast tanks should also be presented.

Range of targets/ambition levels for the instruments

The environmental and economic analysis shall in particular address the following ambition levels for the instruments:

1) Environmentally differentiated shipping dues based on

- A sulphur content of bunker fuel oil at i) 1.5 per cent; ii) 1.0 per cent; or iii) 0.5 per cent
- NO_x emission limits at i) the MARPOL Annex VI Technical code ("IMO-curve" or

an emission below 12g/kWh); ii) 75 per cent of the "IMO-curve" (or an emission below 7g/kWh); and iii) 20 per cent of the "IMO-curve" (or an emission below 2g/kWh)

- 2) Regulated content of sulphur in marine bunker fuel. A sulphur content of bunker fuel oil at i) 1.5 per cent; ii) 1.0 per cent; or iii) 0.5 per cent

Legal aspects

The consultants shall clarify the existing legal framework within which environmentally differentiated port or fairway dues could be introduced, whether this would be individually by each Member State or under an EU regulation.

The consultants shall present the legal aspects of a compulsory or voluntary system of differentiated port or fairway dues, and how such a system would be related to EC legislation.

The consultants shall also clarify the existing international legal framework within which new EC legislation binding the maximum content of sulphur in marine bunker fuels would be introduced, in particular which ships and ship movements could be covered.

Technical aspects

Consultants should estimate the technical requirements for the oil industry to reduce the sulphur in bunker fuels, such as requirements for new investments in the oil refineries, and/or possibilities to change the crude oil and/or to mix fuel qualities.

The consultants should also estimate potential technical improvements (ex. Converters, fuel switching) that exists for shipping, and that a system of differentiated port dues may encourage ship owners to make.

The costs of these different technical options should also be estimated.

Economic and environmental aspect

Based on technical aspects the consultants should estimate the cost for the shipping industry of implementing an EU directive that would require a reduced content of sulphur in bunker fuels to different levels (1.5, 1.0 or 0.5 per cent).

The benefits in the form of reduced emissions from such a reduced content of sulphur in bunker fuels should be estimated. The economic benefits of the reduced emissions should also be estimated.

The impact on overall maritime SO_s/NO_x emissions of introducing differentiated port dues should also be analysed, as well as the costs of achieving different level of emission reduction through such differentiated port dues.

For both potential instruments (regulated bunker fuels or differentiated shipping dues) the economic consequences for frequent ferry traffic and other frequent maritime traffic to and from a Member State and inside a Member State should be estimated (sensitivity analysis for the sector). Effects for more sporadic traffic should also be analysed. The consultants should also assess whether exemptions may be needed.

Possible effects of the instruments on the competition between EU ports and between EU ports and third country ports should also be addressed.

Control aspects

The consultants should identify ways and means to verify that the ships that would pay lower port dues really would be in compliance with the requirements to use lower sulphur content or implement NO_x reducing measures. Technical possibilities such as the use of devices that register fuel quality and use of catalytic converters, fuel sampling in port and at seas should be investigated.

Other aspects

Other possible methods to reduce ship emissions, such as obligatory connection to electrical grid during port visits should be evaluated.